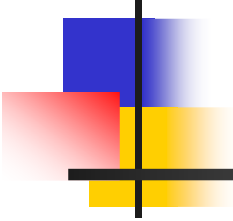


# Specialty Board in Critical Care Medicine

## Critical Care Tutorial



# Scoring Systems in ICU

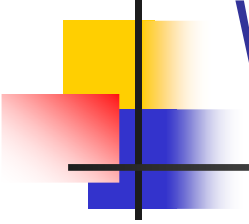
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Dr Yan Wing Wa

Department of Intensive Care

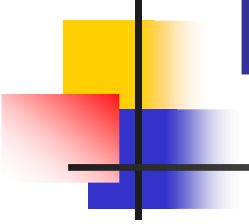
Pamela Youde Nethersole Eastern Hospital

February 2009



# What are the Roles of Scoring Systems?

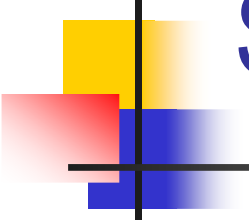
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# Roles of Scoring Systems

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- Comparative audit
  - Standardised mortality ratio
- Evaluative research
  - Risk stratification
- Clinical management of individual patients

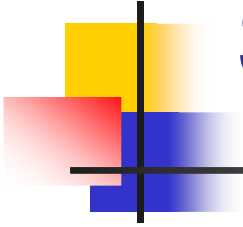


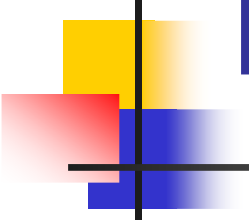
# Scoring Systems

---

- Quantification of case-mix and
- Development of mathematical equations to estimate probabilities of outcome for intensive care patients.
- Outcome parameters:
  - Mortality
  - Morbidity
  - Disability
  - Functional health status
  - Quality of life

# What are the Limitations of Scoring Systems?

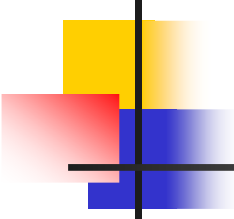




# Limitations of Scoring Systems

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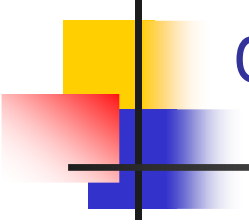
1. Generalisibility of scoring system
  - Different patient inclusion criteria
  - Different time period of data collection
  - Different outcome variable



# Limitations of Scoring System

---

3. Accuracy of scoring system
  - Not perfect
  - Different case-mix
  - Score itself not best prediction but the ROD.



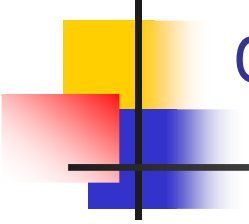
# Use APACHE II system (SMR) to compare two different ICU performance

---

## Drawbacks

1. Case mix differences
2. Definition of hospital discharge
  - ? Convalescent home
3. Mortality: is it really bad
  - Good death >>'bad' survival
4. ICU admission policy
  - (esp. with limit no of bed and under hospital policy)
5. Use of admission diagnosis
6. Inter-rater/intra-rater reliability in data entry
7. Electronic data retrieving data
  - (artifact)
8. GCS data entry
  - (Sedation/coma)



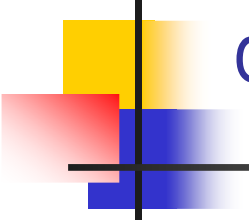


# Use APACHE II system (SMR) to compare two different ICU performance

---

## Drawbacks

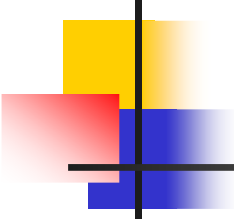
9. Lead time bias
  - (APACHE III better)
10. not just ICU performance
  - Hospital death
  - Post-ICU discharge care
  - Shortage of ICU bed
  - Pre-mature discharge
  - Discharge at odd hours
11. More blood taking
  - ↑ chance of getting worse data
12. Resource put in
  - No of nurses/doctors. Etc.
  - Drugs
  - Consumables and equipments



## Use APACHE II system (SMR) to compare two different ICU performance

---

- Outcome
- Input
- Process



# Scoring System Development

---

- Subjective theoretical approach  
(top-down)
  - experts determine the inclusion of parameters and their weight  
e.g. APACHE, APACHE II, SAPS, TISS
- Objective empirical approach  
(bottom-up)
  - Statistical method to determine factor inclusion and its weight e.g.  
MPM II, APACHE III, APACHE IV

## 2. Physiologic measurements - From 34 to 12

### THE APACHE II SEVERITY OF DISEASE CLASSIFICATION SYSTEM

| PHYSIOLOGIC VARIABLE                                                                     | HIGH ABNORMAL RANGE |                |              |                  |                        | LOW ABNORMAL RANGE      |                |                         |                        |
|------------------------------------------------------------------------------------------|---------------------|----------------|--------------|------------------|------------------------|-------------------------|----------------|-------------------------|------------------------|
|                                                                                          | +4                  | +3             | +2           | +1               | 0                      | +1                      | +2             | +3                      | +4                     |
| TEMPERATURE — rectal (°C)                                                                | ○<br>≥ 41*          | ○<br>39*-40.9* |              | ○<br>38.5*-38.9* | ○<br>36*-38.4*         | ○<br>34*-35.9*          | ○<br>32*-33.9* | ○<br>30*-31.9*          | ○<br>≤ 29.9*           |
| MEAN ARTERIAL PRESSURE — mm Hg                                                           | ○<br>≥ 160          | ○<br>130-159   | ○<br>110-129 |                  | ○<br>70-109            |                         | ○<br>50-69     |                         | ○<br>≤ 49              |
| HEART RATE<br>(ventricular response)                                                     | ○<br>≥ 180          | ○<br>140-179   | ○<br>110-139 |                  | ○<br>70-109            |                         | ○<br>55-69     | ○<br>40-54              | ○<br>≤ 39              |
| RESPIRATORY RATE —<br>(non-ventilated or ventilated)                                     | ○<br>≥ 50           | ○<br>35-49     |              | ○<br>25-34       | ○<br>12-24             | ○<br>10-11              | ○<br>6-9       |                         | ○<br>≤ 5               |
| OXYGENATION: A-aDO <sub>2</sub> or PaO <sub>2</sub> (mm Hg)                              |                     |                |              |                  |                        |                         |                |                         |                        |
| a. FIO <sub>2</sub> ≥ 0.5 record A-aDO <sub>2</sub>                                      | ○<br>≥ 500          | ○<br>350-499   | ○<br>200-349 |                  | ○<br>≤ 200             |                         |                |                         |                        |
| b. FIO <sub>2</sub> < 0.5 record only PaO <sub>2</sub>                                   |                     |                |              |                  | ○ PO <sub>2</sub> > 70 | ○ PO <sub>2</sub> 61-70 |                | ○ PO <sub>2</sub> 55-60 | ○ PO <sub>2</sub> < 55 |
| ARTERIAL pH                                                                              | ○<br>≥ 7.7          | ○<br>7.6-7.69  |              | ○<br>7.5-7.59    | ○<br>7.33-7.49         |                         | ○<br>7.25-7.32 | ○<br>7.15-7.24          | ○<br>< 7.15            |
| SERUM SODIUM (mMol/L)                                                                    | ○<br>≥ 180          | ○<br>160-179   | ○<br>155-159 | ○<br>150-154     | ○<br>130-149           |                         | ○<br>120-129   | ○<br>111-119            | ○<br>≤ 110             |
| SERUM POTASSIUM (mMol/L)                                                                 | ○<br>≥ 7            | ○<br>6-6.9     |              | ○<br>5.5-5.9     | ○<br>3.5-5.4           | ○<br>3-3.4              | ○<br>2.5-2.9   |                         | ○<br>< 2.5             |
| SERUM CREATININE (mg/100 ml)<br>(Double point score for acute renal failure)             | ○<br>≥ 3.5          | ○<br>2-3.4     | ○<br>1.5-1.9 |                  | ○<br>0.6-1.4           |                         | ○<br>< 0.6     |                         |                        |
| HEMATOCRIT (%)                                                                           | ○<br>≥ 60           |                | ○<br>50-59.9 | ○<br>46-49.9     | ○<br>30-45.9           |                         | ○<br>20-29.9   |                         | ○<br>< 20              |
| WHITE BLOOD COUNT (total/mm <sup>3</sup> )<br>(in 1,000s)                                | ○<br>≥ 40           |                | ○<br>20-39.9 | ○<br>15-19.9     | ○<br>3-14.9            |                         | ○<br>1-2.9     |                         | ○<br>< 1               |
| GLASGOW COMA SCORE (GCS):<br>Score = 15 minus actual GCS                                 |                     |                |              |                  |                        |                         |                |                         |                        |
| <b>A</b> Total ACUTE PHYSIOLOGY SCORE (APS):<br>Sum of the 12 individual variable points |                     |                |              |                  |                        |                         |                |                         |                        |
| Serum HCO <sub>3</sub> (venous-mMol/L)<br>[Not preferred, use if no ABGs]                | ○<br>≥ 52           | ○<br>41-51.9   |              | ○<br>32-40.9     | ○<br>22-31.9           |                         | ○<br>18-21.9   | ○<br>15-17.9            | ○<br>< 15              |



|                                                                                        |              |                  |                 |                                  |                |                                                    |                                                         |                                       |                          |                      |                         |                |
|----------------------------------------------------------------------------------------|--------------|------------------|-----------------|----------------------------------|----------------|----------------------------------------------------|---------------------------------------------------------|---------------------------------------|--------------------------|----------------------|-------------------------|----------------|
|                                                                                        |              |                  |                 | 8<br>≤ 39                        | 5<br>40-49     | Pulse 0<br>50-99 beats/min                         | 1<br>100-109                                            | 5<br>110-119                          | 7<br>120-139             | 13<br>140-154        | 17<br>≥ 155             |                |
| 23<br>≤ 39                                                                             | 15<br>40-59  |                  |                 |                                  | 7<br>60-69     | 6<br>70-79                                         | 0 Mean BP<br>80-99 mmHg                                 | 4<br>100-119                          | 7<br>120-129             | 9<br>130-139         | 10<br>≥ 140             |                |
|                                                                                        | 20<br>≤ 32.9 | 16<br>33-33.4    | 13<br>33.5-33.9 | 8<br>34-34.9                     |                | 2<br>35-35.9                                       | 0 Temperature<br>36-39.9°C                              | 4<br>≥ 40                             |                          |                      |                         |                |
| *For patients on mechanical ventilation no points are given for respiratory rates 6-12 |              | 17<br>≤ 5        | 6-11*           |                                  | 8<br>12-13     | 7<br>13                                            | 0 *Respiratory rate<br>14-24 breaths/min                |                                       | 6<br>25-34               | 9<br>35-39           | 11<br>40-49             | 18<br>≥ 50     |
|                                                                                        |              |                  | 15<br>≤ 49      | 50-69                            |                | 5<br>70-79                                         | 2<br>≥ 80 mmHg                                          | 0 † PaO <sub>2</sub>                  |                          |                      |                         |                |
|                                                                                        |              |                  |                 |                                  |                |                                                    |                                                         | 0 † D(A-a)O <sub>2</sub><br>≤ 100     | 7<br>100-249             | 9<br>250-349         | 11<br>350-499           | 14<br>≥ 500    |
|                                                                                        |              |                  |                 |                                  |                | 3<br>≤ 40-49                                       | 0 Hematocrit<br>41-49%                                  | 3<br>≥ 50                             |                          |                      |                         |                |
| 19<br>≤ 10                                                                             | 10-29        |                  |                 |                                  | 5              | WBC 0<br>3.0-19.9 10 <sup>3</sup> /mm <sup>3</sup> | 1<br>20-24.9                                            | 5<br>≥ 25                             |                          |                      |                         |                |
|                                                                                        |              |                  |                 |                                  |                | 3<br>≤ 0.4                                         | 0 ‡ Creatinine s/ARF<br>44-132 μmol/dl<br>0.5-1.4 mg/dl | 4<br>133-171<br>1.5-1.94              | 7<br>≥ 172<br>≥ 1.95     |                      |                         |                |
|                                                                                        |              |                  |                 |                                  |                |                                                    | 0 ‡ Creatinine c/ARF<br>0-132 mol/dL<br>0-1.4 mg/dl     |                                       | 10<br>≥ 133<br>≥ 1.5     |                      |                         |                |
|                                                                                        | 15<br>≤ 399  | 8<br>400-599     | 7<br>600-899    | 5<br>900-1499                    | 4<br>1500-1999 | Urine output 0<br>2000-3999 cm <sup>3</sup> /day   | 1<br>≥ 4000                                             |                                       |                          |                      |                         |                |
|                                                                                        |              |                  |                 |                                  |                | 0 BUN<br>≤ 6.1 mmol/l<br>≥ 16.9 mg/dl              | 2<br>6.2-7.1<br>17-19                                   | 7<br>7.2-14.3<br>20-39                | 11<br>14.4-28.5<br>40-79 | 12<br>≥ 28.6<br>≥ 80 |                         |                |
|                                                                                        |              |                  |                 |                                  |                | 3<br>≤ 119<br>≤ 119                                | 0 Sodium<br>120-134<br>120-134                          | 21<br>135-154 mmol/l<br>135-154 mEq/l | 4<br>≥ 155<br>≥ 155      |                      |                         |                |
|                                                                                        | 11<br>≤ 1.9  | 20-24<br>2.0-2.4 |                 | 6                                |                | 25.44 g/l<br>2.5-4.4 g/dl                          | 0 Albumin                                               | 4<br>≥ 45<br>≥ 4.5                    |                          |                      |                         |                |
|                                                                                        |              |                  |                 |                                  |                |                                                    | 0 Bilirubin<br>≤ 34 μmol/l<br>≤ 1.9 mg/dl               | 5<br>35-51<br>2.0-2.9                 | 6<br>52-85<br>3.0-4.9    | 8                    | 16<br>86-135<br>5.0-7.9 | ≥ 136<br>≥ 8.0 |
| §Glucose ≤ 39 mg/dl is lower weight than 40-59                                         |              | 8<br>≤ 2.1       | 9<br>2.2-3.3    | 3.4-11.1 mmol/dl<br>60-199 mg/dl |                | 0 Glucose                                          | 3<br>11.2-19.3<br>200-349                               | 5<br>≥ 19.4<br>≥ 350                  |                          |                      |                         |                |

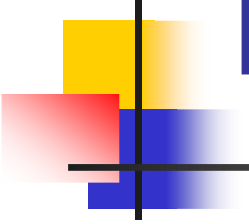
†Only use D(A-a)O<sub>2</sub> for intubated patients with FIO<sub>2</sub> ≥ 0.5. Do not use PaO<sub>2</sub> weights for these patients.

‡Acute renal failure (ARF) is defined as creatinine ≥ 1.5 mg/day and urine output < 410 cm<sup>3</sup>/day and no chronic dialysis

†Only use D(A-a)O<sub>2</sub> for intubated patients with FIO<sub>2</sub> ≥ 0.5. Do not use Pao<sub>2</sub> weights for these patients

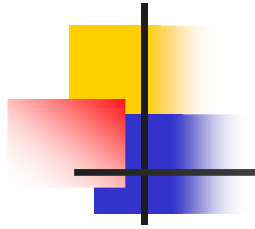
‡Acute renal failure (ARF) is defined as creatinine ≥ 1.5 mg/day and urine output < 410 cm<sup>3</sup>/day and no chronic dialysis

Fig. 2 APACHE III scoring for vital signs and laboratory abnormalities. (Reproduced with permission from Knaus *et al.* (1991).)



# How to validate a scoring system?

---



Scores



Risk of Death

Mathematical Model  
(Goodness of fit model)

## Calibration

Hosmer-Lemeshow

$\hat{C}$  statistics

$\hat{H}$  statistics

Test extent of agreement between  
expected and observed death across  
all subgroups of patients

## Discrimination

ROC

Test the ability to discriminate live  
and death

## Hosmer-Lemeshow Goodness-of-Fit (C test) – Original models

### APACHE II

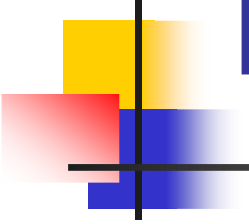
| Predicted Mortality<br>Within Decile (%) |   |       | # of<br>Admissions | Observed<br>Deaths | Expected<br>Deaths | Observed<br>Survivors | Expected<br>Survivors | H-L<br>Statistic |
|------------------------------------------|---|-------|--------------------|--------------------|--------------------|-----------------------|-----------------------|------------------|
| 0.001                                    | - | 0.033 | 468                | 2                  | 8.9                | 466                   | 459.1                 | 5.46             |
| 0.033                                    | - | 0.056 | 457                | 9                  | 20.4               | 448                   | 436.6                 | 6.63             |
| 0.056                                    | - | 0.081 | 463                | 16                 | 31.0               | 447                   | 432.0                 | 7.74             |
| 0.081                                    | - | 0.109 | 465                | 13                 | 43.9               | 452                   | 421.1                 | 24.05            |
| 0.110                                    | - | 0.146 | 467                | 32                 | 59.5               | 435                   | 407.5                 | 14.54            |
| 0.146                                    | - | 0.201 | 456                | 47                 | 78.5               | 409                   | 377.5                 | 15.24            |
| 0.201                                    | - | 0.263 | 462                | 62                 | 106.2              | 400                   | 355.8                 | 23.87            |
| 0.265                                    | - | 0.387 | 468                | 85                 | 148.5              | 383                   | 319.5                 | 39.75            |
| 0.389                                    | - | 0.577 | 463                | 165                | 220.7              | 298                   | 242.3                 | 26.84            |
| 0.577                                    | - | 0.996 | 461                | 279                | 342.1              | 182                   | 118.9                 | 45.09            |
| Total                                    |   |       | 4630               | 710                | 1059.5             | 3920                  | 3570.5                | 209.20           |
| C= 209.20      df 10, p < 0.0001         |   |       |                    |                    |                    |                       |                       |                  |



## Hosmer-Lemeshow Goodness-of-Fit (H test) – Original models

### APACHE II

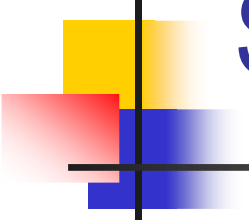
| Predicted Mortality<br>Within Decile (%) |   |       | # of<br>Admissions | Observed<br>Deaths | Expected<br>Deaths | Observed<br>Survivors | Expected<br>Survivors | H-L<br>Statistic |
|------------------------------------------|---|-------|--------------------|--------------------|--------------------|-----------------------|-----------------------|------------------|
| 0.001                                    | - | 0.099 | 1720               | 36                 | 90.0               | 1684                  | 1630.0                | 34.21            |
| 0.100                                    | - | 0.199 | 1052               | 82                 | 151.2              | 970                   | 900.8                 | 37.03            |
| 0.201                                    | - | 0.300 | 650                | 95                 | 159.0              | 555                   | 491.0                 | 34.08            |
| 0.300                                    | - | 0.399 | 323                | 62                 | 111.8              | 261                   | 211.2                 | 33.96            |
| 0.402                                    | - | 0.498 | 267                | 88                 | 120.3              | 179                   | 146.7                 | 15.79            |
| 0.500                                    | - | 0.598 | 192                | 80                 | 105.6              | 112                   | 86.4                  | 13.80            |
| 0.602                                    | - | 0.699 | 161                | 73                 | 103.9              | 88                    | 57.1                  | 25.95            |
| 0.700                                    | - | 0.798 | 101                | 66                 | 75.3               | 35                    | 25.7                  | 4.49             |
| 0.801                                    | - | 0.898 | 120                | 91                 | 101.0              | 29                    | 19.0                  | 6.29             |
| 0.902                                    | - | 0.996 | 44                 | 37                 | 41.3               | 7                     | 2.7                   | 7.10             |
| Total                                    |   |       | 4630               | 710                | 1059.5             | 3920                  | 3570.5                | 212.70           |
| H= 212.70                                |   |       |                    |                    |                    |                       | df 10, p < 0.0001     |                  |



# How to classify scoring systems?

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# Classification of Scoring systems for ICU



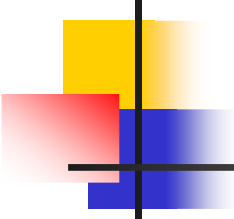
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- General

- TISS, APACHE, SAPS, MPM

- Specific

- SOFA, MODS: sepsis of multi-organ failure
- GCS: conscious status
- TRISS: trauma patient



# General scoring systems

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- APACHE
  - APACHE II
  - APACHE III
  - APACHE IV
- SAPS
  - SAPS II
  - SAPS 3
- MPM
  - MPM<sub>0</sub>
  - MPM<sub>24</sub>
  - MPM<sub>48</sub> & MPM<sub>72</sub>



# APACHE II

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# APACHE II: A severity of disease classification system

W.A. Knaus et al. Crit Care med 1985; 10:818

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1. Original APACHE system. Crit Care Med 1981; 9:591
  - 34 physiologic measures (0-4)
    - Sum of all acute physiology scores (APS)
    - Worst of the initial 24 hour after ICU admission
  - Chronic health
    - A (excellent health)
    - B
    - C
    - D (severe chronic organ system insufficiency)
  - Complex
  - Need formal multi-institutional validation

## 2. Physiologic measurements - From 34 to 12

### THE APACHE II SEVERITY OF DISEASE CLASSIFICATION SYSTEM

| PHYSIOLOGIC VARIABLE                                                                     | HIGH ABNORMAL RANGE |                |              |                  |                        | LOW ABNORMAL RANGE      |                |                         |                        |
|------------------------------------------------------------------------------------------|---------------------|----------------|--------------|------------------|------------------------|-------------------------|----------------|-------------------------|------------------------|
|                                                                                          | +4                  | +3             | +2           | +1               | 0                      | +1                      | +2             | +3                      | +4                     |
| TEMPERATURE — rectal (°C)                                                                | ○<br>≥ 41*          | ○<br>39*-40.9* |              | ○<br>38.5*-38.9* | ○<br>36*-38.4*         | ○<br>34*-35.9*          | ○<br>32*-33.9* | ○<br>30*-31.9*          | ○<br>≤ 29.9*           |
| MEAN ARTERIAL PRESSURE — mm Hg                                                           | ○<br>≥ 160          | ○<br>130-159   | ○<br>110-129 |                  | ○<br>70-109            |                         | ○<br>50-69     |                         | ○<br>≤ 49              |
| HEART RATE<br>(ventricular response)                                                     | ○<br>≥ 180          | ○<br>140-179   | ○<br>110-139 |                  | ○<br>70-109            |                         | ○<br>55-69     | ○<br>40-54              | ○<br>≤ 39              |
| RESPIRATORY RATE —<br>(non-ventilated or ventilated)                                     | ○<br>≥ 50           | ○<br>35-49     |              | ○<br>25-34       | ○<br>12-24             | ○<br>10-11              | ○<br>6-9       |                         | ○<br>≤ 5               |
| OXYGENATION: A-aDO <sub>2</sub> or PaO <sub>2</sub> (mm Hg)                              |                     |                |              |                  |                        |                         |                |                         |                        |
| a. FIO <sub>2</sub> ≥ 0.5 record A-aDO <sub>2</sub>                                      | ○<br>≥ 500          | ○<br>350-499   | ○<br>200-349 |                  | ○<br>≤ 200             |                         |                |                         |                        |
| b. FIO <sub>2</sub> < 0.5 record only PaO <sub>2</sub>                                   |                     |                |              |                  | ○ PO <sub>2</sub> > 70 | ○ PO <sub>2</sub> 61-70 |                | ○ PO <sub>2</sub> 55-60 | ○ PO <sub>2</sub> < 55 |
| ARTERIAL pH                                                                              | ○<br>≥ 7.7          | ○<br>7.6-7.69  |              | ○<br>7.5-7.59    | ○<br>7.33-7.49         |                         | ○<br>7.25-7.32 | ○<br>7.15-7.24          | ○<br>< 7.15            |
| SERUM SODIUM (mMol/L)                                                                    | ○<br>≥ 180          | ○<br>160-179   | ○<br>155-159 | ○<br>150-154     | ○<br>130-149           |                         | ○<br>120-129   | ○<br>111-119            | ○<br>≤ 110             |
| SERUM POTASSIUM (mMol/L)                                                                 | ○<br>≥ 7            | ○<br>6-6.9     |              | ○<br>5.5-5.9     | ○<br>3.5-5.4           | ○<br>3-3.4              | ○<br>2.5-2.9   |                         | ○<br>< 2.5             |
| SERUM CREATININE (mg/100 ml)<br>(Double point score for acute renal failure)             | ○<br>≥ 3.5          | ○<br>2-3.4     | ○<br>1.5-1.9 |                  | ○<br>0.6-1.4           |                         | ○<br>< 0.6     |                         |                        |
| HEMATOCRIT (%)                                                                           | ○<br>≥ 60           |                | ○<br>50-59.9 | ○<br>46-49.9     | ○<br>30-45.9           |                         | ○<br>20-29.9   |                         | ○<br>< 20              |
| WHITE BLOOD COUNT (total/mm <sup>3</sup> )<br>(in 1,000s)                                | ○<br>≥ 40           |                | ○<br>20-39.9 | ○<br>15-19.9     | ○<br>3-14.9            |                         | ○<br>1-2.9     |                         | ○<br>< 1               |
| GLASGOW COMA SCORE (GCS):<br>Score = 15 minus actual GCS                                 |                     |                |              |                  |                        |                         |                |                         |                        |
| <b>A</b> Total ACUTE PHYSIOLOGY SCORE (APS):<br>Sum of the 12 individual variable points |                     |                |              |                  |                        |                         |                |                         |                        |
| Serum HCO <sub>3</sub> (venous-mMol/L)<br>[Not preferred, use if no ABGs]                | ○<br>≥ 52           | ○<br>41-51.9   |              | ○<br>32-40.9     | ○<br>22-31.9           |                         | ○<br>18-21.9   | ○<br>15-17.9            | ○<br>< 15              |

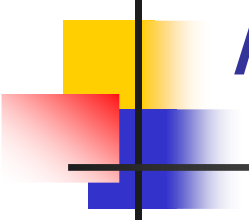
# THE APACHE II SEVERITY OF DISEASE CLASSIFICATION SYSTEM

| PHYSIOLOGIC VARIABLE                                                            | HIGH ABNORMAL RANGE |           |         |             |                      | LOW ABNORMAL RANGE    |           |                       |                      |  |
|---------------------------------------------------------------------------------|---------------------|-----------|---------|-------------|----------------------|-----------------------|-----------|-----------------------|----------------------|--|
|                                                                                 | +4                  | +3        | +2      | +1          | 0                    | +1                    | +2        | +3                    | +4                   |  |
| TEMPERATURE — rectal (°C)                                                       | ≥ 41*               | 39*–40.9* |         | 38.5*–38.9* | 36*–38.4*            | 34*–35.9*             | 32*–33.9* | 30*–31.9*             | ≤ 29.9*              |  |
| MEAN ARTERIAL PRESSURE — mm Hg                                                  | ≥ 160               | 130–159   | 110–129 |             | 70–109               |                       | 50–69     |                       | ≤ 49                 |  |
| HEART RATE<br>(ventricular response)                                            | ≥ 180               | 140–179   | 110–139 |             | 70–109               |                       | 55–69     | 40–54                 | ≤ 39                 |  |
| RESPIRATORY RATE —<br>(non-ventilated or ventilated)                            | ≥ 50                | 35–49     |         | 25–34       | 12–24                | 10–11                 | 6–9       |                       | ≤ 5                  |  |
| OXYGENATION: A-aDO <sub>2</sub> or PaO <sub>2</sub> (mm Hg)                     |                     |           |         |             |                      |                       |           |                       |                      |  |
| a. FiO <sub>2</sub> ≥ 0.5 record A-aDO <sub>2</sub>                             | ≥ 500               | 350–499   | 200–349 |             | ≤ 200                |                       |           |                       |                      |  |
| b. FiO <sub>2</sub> < 0.5 record only PaO <sub>2</sub>                          |                     |           |         |             | PO <sub>2</sub> ≥ 70 | PO <sub>2</sub> 61–70 |           | PO <sub>2</sub> 55–60 | PO <sub>2</sub> < 55 |  |
| ARTERIAL pH                                                                     | ≥ 7.7               | 7.6–7.69  |         | 7.5–7.59    | 7.33–7.49            |                       | 7.25–7.32 | 7.15–7.24             | < 7.15               |  |
| SERUM SODIUM (mMol/L)                                                           | ≥ 180               | 160–179   | 155–159 | 150–154     | 130–149              |                       | 120–129   | 111–119               | ≤ 110                |  |
| SERUM POTASSIUM (mMol/L)                                                        | ≥ 7                 | 6–6.9     |         | 5.5–5.9     | 3.5–5.4              | 3–3.4                 | 2.5–2.9   |                       | < 2.5                |  |
| SERUM CREATININE (mg/100 ml)<br>(Double point score for acute renal failure)    | ≥ 3.5               | 2–3.4     | 1.5–1.9 |             | 0.6–1.4              |                       | < 0.6     |                       |                      |  |
| HEMATOCRIT (%)                                                                  | ≥ 60                |           | 50–59.9 | 46–49.9     | 30–45.9              |                       | 20–29.9   |                       | < 20                 |  |
| WHITE BLOOD COUNT (total/mm <sup>3</sup> )<br>(in 1,000s)                       | ≥ 40                |           | 20–39.9 | 15–19.9     | 3–14.9               |                       | 1–2.9     |                       | < 1                  |  |
| GLASGOW COMA SCORE (GCS):<br>Score = 15 minus actual GCS                        |                     |           |         |             |                      |                       |           |                       |                      |  |
| Total ACUTE PHYSIOLOGY SCORE (APS):<br>Sum of the 12 individual variable points |                     |           |         |             |                      |                       |           |                       |                      |  |
| Serum HCO <sub>3</sub> (venous-mMol/L)<br>[Not preferred, use if no ABGs]       | ≥ 52                | 41–51.9   |         | 32–40.9     | 22–31.9              |                       | 18–21.9   | 15–17.9               | < 15                 |  |

## 2. Physiologic measurements

- A lot of multi-variate comparison of the original variable had been made.
- ↑ weighting for GCS
- Creatinine weighting:
  - Double if acute renal failure
- For FiO<sub>2</sub> < 0.5, direct weighting based on PaO<sub>2</sub> rather than P(A-a)O<sub>2</sub>.
- Worst reading over initial 24 hours in ICU.





# APACHE II

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## 3. Age

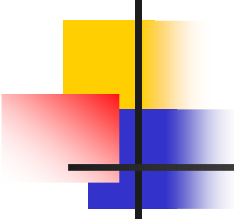
- Well documented independent risk factor for death

**B**

### **AGE POINTS:**

Assign points to age as follows:

| AGE (yrs) | Points |
|-----------|--------|
| $\leq 44$ | 0      |
| 45-54     | 2      |
| 55-64     | 3      |
| 65-74     | 5      |
| $\geq 75$ | 6      |



# APACHE II

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## 4. Clinical health classification

- Only the original most severe category D markedly influenced the outcome

C

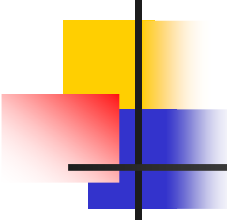
### **CHRONIC HEALTH POINTS**

If the patient has a history of severe organ system insufficiency or is immuno-compromised assign points as follows:

- a. For nonoperative or emergency postoperative patient – 5 points.

**OR**

- b. For elective postoperative patient – 2 points



# APACHE II

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## C

### DEFINITIONS

Organ Insufficiency or immuno-compromised state must have been evident **prior** to this hospital admission and conform to the following criteria:

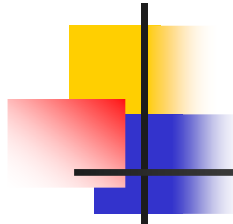
LIVER: Biopsy proven cirrhosis and documented portal hypertension; episodes of past upper GI bleeding attributed to portal hypertension; or prior episodes of hepatic failure/encephalopathy/coma.

CARDIOVASCULAR: New York Heart Association Class IV.

RESPIRATORY: Chronic restrictive, obstructive, or vascular disease resulting in severe exercise restriction, i.e., unable to climb stairs or perform household duties; or documented chronic hypoxia, hypercapnia, secondary polycythemia, severe pulmonary hypertension (>40 mmHg), or respirator dependency.

RENAL: Receiving chronic dialysis.

IMMUNO-COMPROMISED: The patient has received therapy that suppresses resistance to infection, e.g. immuno-suppression, chemotherapy, radiation, long term or recent high dose steroids, or has a disease that is sufficiently advanced to suppress resistance to infection.e.g. leukemia, lymphoma, AIDS.



# APACHE II

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5. APACHE II score (0 – 71)

■  $A+B+C$

## APACHE II SCORE

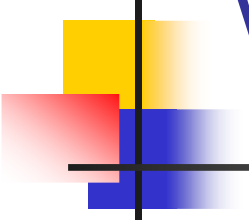
Sum of A + B + C

A APS points \_\_\_\_\_

B Age points \_\_\_\_\_

C Chronic Health points \_\_\_\_\_

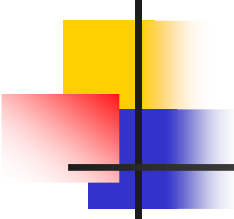
Total APACHE II \_\_\_\_\_



# Validation Process

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- 13 US hospitals
  - George Washington University Medical Centre: 1979-1981
  - Other 12 hospitals: 1982
- 5815 admissions



# APACHE II

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7. R: (Risk of hospital death)

$$\ln(\text{odds of R}) = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + \dots$$

$$\begin{aligned} \ln(R/1-R) = & - 3.517 + 0.146 \text{ score} \\ & + 0.603 (1 \text{ for emergency OT, otherwise } 0) \\ & + (\text{diagnostic category weight}) \end{aligned}$$

50 diagnostic categories

# APPENDIX

To compute predicted death rates for groups of acutely ill patients, for each individual compute the risk (R) of hospital death with the following equation; then sum the individual risks and divide by the total number of patients.

$$\ln(R/1-R) = -3.517 + (\text{APACHE II score} \times 0.146) \\ + (0.603, \text{ only if postemergency surgery}) \\ + (\text{Diagnostic category weight, as shown below})$$

## Principal Diagnostic Categories Leading to ICU Admission

### Nonoperative patients

#### Respiratory failure or insufficiency from:

|                                  |        |
|----------------------------------|--------|
| Asthma/allergy                   | -2.108 |
| COPD                             | -0.367 |
| Pulmonary edema (noncardiogenic) | -0.251 |
| Postrespiratory arrest           | -0.168 |
| Aspiration/poisoning/toxic       | -0.142 |
| Pulmonary embolus                | -0.128 |
| Infection                        | 0      |
| Neoplasm                         | 0.891  |

#### Cardiovascular failure or insufficiency from:

|                                        |        |
|----------------------------------------|--------|
| Hypertension                           | -1.798 |
| Rhythm disturbance                     | -1.368 |
| Congestive heart failure               | -0.424 |
| Hemorrhagic shock/hypovolemia          | 0.493  |
| Coronary artery disease                | -0.191 |
| Sepsis                                 | 0.113  |
| Postcardiac arrest                     | 0.393  |
| Cardiogenic shock                      | -0.259 |
| Dissecting thoracic/abdominal aneurysm | 0.731  |

#### Trauma:

|                 |        |
|-----------------|--------|
| Multiple trauma | -1.228 |
| Head trauma     | -0.517 |

#### Neurologic:

|                  |        |
|------------------|--------|
| Seizure disorder | -0.584 |
| ICH/SDH/SAH      | 0.723  |

#### Other:

|                       |        |
|-----------------------|--------|
| Drug overdose         | -3.353 |
| Diabetic ketoacidosis | -1.507 |
| GI bleeding           | 0.334  |

If not in one of the specific groups above, then which major vital organ system was the principal reason for admission?

|                  |        |
|------------------|--------|
| Metabolic/renal  | -0.885 |
| Respiratory      | -0.890 |
| Neurologic       | -0.759 |
| Cardiovascular   | 0.470  |
| Gastrointestinal | 0.501  |

### Postoperative patients

|                                                 |        |
|-------------------------------------------------|--------|
| Multiple trauma                                 | -1.684 |
| Admission due to chronic cardiovascular disease | -1.376 |
| Peripheral vascular surgery                     | -1.315 |
| Heart valve surgery                             | -1.261 |
| Craniotomy for neoplasm                         | -1.245 |
| Renal surgery for neoplasm                      | -1.204 |
| Renal transplant                                | -1.042 |
| Head trauma                                     | -0.955 |
| Thoracic surgery for neoplasm                   | -0.802 |
| Craniotomy for ICH/SDH/SAH                      | -0.788 |
| Laminectomy and other spinal cord surgery       | -0.699 |
| Hemorrhagic shock                               | -0.682 |
| GI bleeding                                     | -0.617 |
| GI surgery for neoplasm                         | -0.248 |
| Respiratory insufficiency after surgery         | -0.140 |
| GI perforation/obstruction                      | 0.060  |

For postoperative patients admitted to the ICU for sepsis or postarrest, use the corresponding weights for nonoperative patients.

If not in one of the above, which major vital organ system led to ICU admission postsurgery?

|                  |        |
|------------------|--------|
| Neurologic       | -1.150 |
| Cardiovascular   | -0.797 |
| Respiratory      | -0.610 |
| Gastrointestinal | -0.613 |
| Metabolic/renal  | -0.196 |

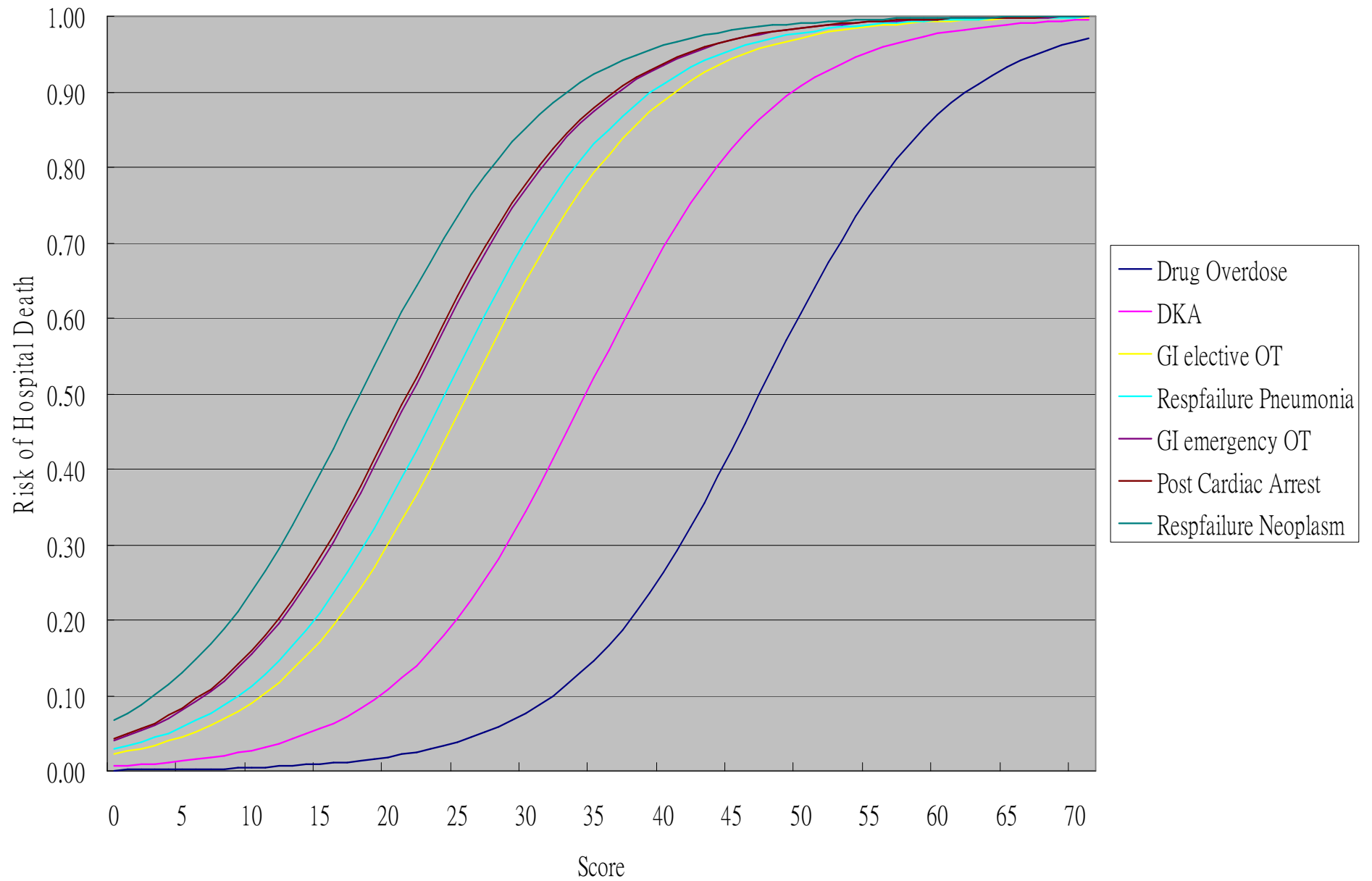
*For Example:* A patient admitted with noncardiogenic pulmonary edema (nonoperative) having 15 APACHE II points would have the following estimated risk:

$$\begin{aligned}\ln (R/1-R) &= -3.517 + (15 \times 0.146) \\ &\quad + (0 \times 0.603) - 0.251 \\ &= -3.517 + 2.19 + 0 - 0.251 \\ &= -1.578\end{aligned}$$

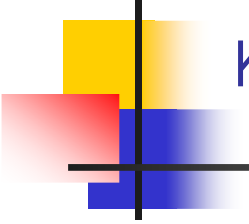
Since the exponential of  $-1.578$  is  $+0.206$ , then  $(R/1-R)$  equals  $+0.206$ , and  $R$  is  $0.17$  or  $17\%$  estimated risk of hospital death.



# APACHE II scoring system





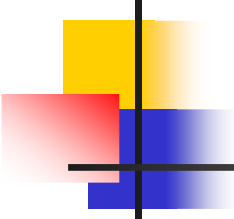


# APACHE III

Knaus WA et al, Chest 1991, 100:1619 - 1636

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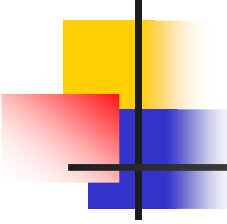
- Developed in 1991
- Data collected in 1988 to 1990
- 17,440 admissions in US hospitals
- Involved 42 ICUs at 40 hospitals



# APACHE III

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- Re-evaluate the selection & weighting of physiological variables
- Update & expand the size & representativeness of reference database
- Examine relationship between outcome & patients selection for & timing of intensive care admission
- Distinguish the use of predictive estimates for patient groups from mortality estimates for individual patients



# APACHE III

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- 17 physiological variables
- Acid-base disturbances
- GCS score – based on the worst
  - Weighting adjusted for interactions between ocular, verbal and motor responses
- Age score
- 7 comorbidities (cardiac, respiratory and renal failures excluded)
- Total score (0 – 299)



|                                                                                        |              |                  |                 |                                  |                |                                                    |                                                         |                                       |                          |                      |                         |                |
|----------------------------------------------------------------------------------------|--------------|------------------|-----------------|----------------------------------|----------------|----------------------------------------------------|---------------------------------------------------------|---------------------------------------|--------------------------|----------------------|-------------------------|----------------|
|                                                                                        |              |                  |                 | 8<br>≤ 39                        | 5<br>40-49     | Pulse 0<br>50-99 beats/min                         | 1<br>100-109                                            | 5<br>110-119                          | 7<br>120-139             | 13<br>140-154        | 17<br>≥ 155             |                |
| 23<br>≤ 39                                                                             | 15<br>40-59  |                  |                 |                                  | 7<br>60-69     | 6<br>70-79                                         | 0 Mean BP<br>80-99 mmHg                                 | 4<br>100-119                          | 7<br>120-129             | 9<br>130-139         | 10<br>≥ 140             |                |
|                                                                                        | 20<br>≤ 32.9 | 16<br>33-33.4    | 13<br>33.5-33.9 | 8<br>34-34.9                     |                | 2<br>35-35.9                                       | 0 Temperature<br>36-39.9°C                              | 4<br>≥ 40                             |                          |                      |                         |                |
| *For patients on mechanical ventilation no points are given for respiratory rates 6-12 |              | 17<br>≤ 5        | 6-11*           |                                  | 8<br>12-13     | 7<br>13                                            | 0 *Respiratory rate<br>14-24 breaths/min                |                                       | 6<br>25-34               | 9<br>35-39           | 11<br>40-49             | 18<br>≥ 50     |
|                                                                                        |              |                  | 15<br>≤ 49      | 50-69                            |                | 5<br>70-79                                         | 2<br>≥ 80 mmHg                                          | 0 † PaO <sub>2</sub>                  |                          |                      |                         |                |
|                                                                                        |              |                  |                 |                                  |                |                                                    | 0 † D(A-a)O <sub>2</sub><br><100                        |                                       | 7<br>100-249             | 9<br>250-349         | 11<br>350-499           | 14<br>≥ 500    |
|                                                                                        |              |                  |                 |                                  |                | 3<br>≤ 40-49                                       | 0 Hematocrit<br>41-49%                                  | 3<br>≥ 50                             |                          |                      |                         |                |
| 19<br><10                                                                              | 10-29        |                  |                 |                                  | 5              | WBC 0<br>3.0-19.9 10 <sup>3</sup> /mm <sup>3</sup> | 1<br>20-24.9                                            | 5<br>≥ 25                             |                          |                      |                         |                |
|                                                                                        |              |                  |                 |                                  |                | 3<br>< 43<br>≤ 0.4                                 | 0 ‡ Creatinine s/ARF<br>44-132 μmol/dl<br>0.5-1.4 mg/dl | 4<br>133-171<br>1.5-1.94              | 7<br>≥ 172<br>≥ 1.95     |                      |                         |                |
|                                                                                        |              |                  |                 |                                  |                |                                                    | 0 ‡ Creatinine c/ARF<br>0-132 mol/dL<br>0-1.4 mg/dl     |                                       | 10<br>≥ 133<br>≥ 1.5     |                      |                         |                |
|                                                                                        | 15<br>≤ 399  | 8<br>400-599     | 7<br>600-899    | 5<br>900-1499                    | 4<br>1500-1999 | Urine output 0<br>2000-3999 cm <sup>3</sup> /day   | 1<br>≥ 4000                                             |                                       |                          |                      |                         |                |
|                                                                                        |              |                  |                 |                                  |                | 0 BUN<br>≤ 6.1 mmol/l<br>≥ 16.9 mg/dl              | 2<br>6.2-7.1<br>17-19                                   | 7<br>7.2-14.3<br>20-39                | 11<br>14.4-28.5<br>40-79 | 12<br>≥ 28.6<br>≥ 80 |                         |                |
|                                                                                        |              |                  |                 |                                  |                | 3<br>≤ 119<br>≤ 119                                | 0 Sodium<br>120-134<br>120-134                          | 21<br>135-154 mmol/l<br>135-154 mEq/l | 4<br>≥ 155<br>≥ 155      |                      |                         |                |
|                                                                                        | 11<br>≤ 1.9  | 20-24<br>2.0-2.4 |                 | 6                                |                | 25.44 g/l<br>2.5-4.4 g/dl                          | 0 Albumin                                               | 4<br>≥ 45<br>≥ 4.5                    |                          |                      |                         |                |
|                                                                                        |              |                  |                 |                                  |                |                                                    | 0 Bilirubin<br>≤ 34 μmol/l<br>≤ 1.9 mg/dl               | 5<br>35-51<br>2.0-2.9                 | 6<br>52-85<br>3.0-4.9    | 8                    | 16<br>86-135<br>5.0-7.9 | ≥ 136<br>≥ 8.0 |
| §Glucose ≤ 39 mg/dl is lower weight than 40-59                                         |              | 8<br>≤ 2.1       | 9<br>2.2-3.3    | 3.4-11.1 mmol/dl<br>60-199 mg/dl |                | 0 Glucose                                          | 3<br>11.2-19.3<br>200-349                               | 5<br>≥ 19.4<br>≥ 350                  |                          |                      |                         |                |

†Only use D(A-a)O<sub>2</sub> for intubated patients with FIO<sub>2</sub> ≥ 0.5. Do not use PaO<sub>2</sub> weights for these patients

‡Acute renal failure (ARF) is defined as creatinine ≥ 1.5 mg/day and urine output < 410 cm<sup>3</sup>/day and no chronic dialysis

†Only use D(A-a)O<sub>2</sub> for intubated patients with FIO<sub>2</sub> ≥ 0.5. Do not use Pao<sub>2</sub> weights for these patients

‡Acute renal failure (ARF) is defined as creatinine ≥ 1.5 mg/day and urine output < 410 cm<sup>3</sup>/day and no chronic dialysis

Fig. 2 APACHE III scoring for vital signs and laboratory abnormalities. (Reproduced with permission from Knaus *et al.* (1991).)

# APACHE III

| Eyes open spontaneously or to painful/verbal stimulation |          |                          |                                                       |                |
|----------------------------------------------------------|----------|--------------------------|-------------------------------------------------------|----------------|
| Verbal<br>Motor                                          | Oriented | Confused<br>conversation | Inappropriate words<br>and incomprehensible<br>sounds | No<br>response |
| Obeys verbal<br>command                                  | 0        | 3                        | 10                                                    | 15             |
| Localizes pain                                           | 3        | 8                        | 13                                                    | 15             |
| Flexion<br>withdrawal /<br>decorticate<br>rigidity       | 3        | 13                       | 24                                                    | 24             |
| Decerebrate<br>rigidity / no<br>response                 | 3        | 13                       | 29                                                    | 29             |

The shaded areas without scores represent unusual and unlikely clinical combinations. There were few or no cases in these cells. For the shaded areas with scores we had data that permit us to extrapolate values. Placing a patient in any of these cells should be done after careful confirmation of clinical findings.



# APACHE III

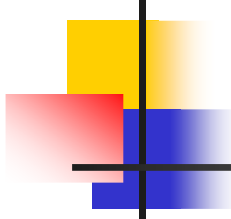
| Eyes do not open spontaneously or to painful/verbal stimulation |          |                          |                                                       |                |
|-----------------------------------------------------------------|----------|--------------------------|-------------------------------------------------------|----------------|
| Verbal<br>Motor                                                 | Oriented | Confused<br>conversation | Inappropriate words<br>and incomprehensible<br>sounds | No<br>response |
| Obeys verbal<br>command                                         |          |                          |                                                       | 16             |
| Localizes pain                                                  |          |                          |                                                       | 16             |
| Flexion<br>withdrawal /<br>decorticate<br>rigidity              |          |                          | 24                                                    | 33             |
| Decerebrate<br>rigidity / no<br>response                        |          |                          | 29                                                    | 48             |

The shaded areas without scores represent unusual and unlikely clinical combinations. There were few or no cases in these cells. For the shaded areas with scores we had data that permit us to extrapolate values. Placing a patient in any of these cells should be done after careful confirmation of clinical findings.



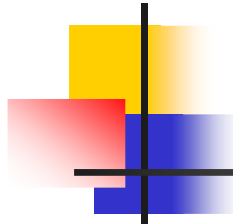
# APACHE III scoring for acid-base disturbances.

| $\text{pH} \backslash P_{\text{CO}_2}$ | < 25 | 25-<30 | 30-<35 | 35-<40 | 40-<45 | 45-<50 | 50-<55 | 55-<60 | $\geq 60$ |
|----------------------------------------|------|--------|--------|--------|--------|--------|--------|--------|-----------|
| <7.15                                  | 12   |        |        |        |        |        | 4      |        |           |
| 7.15-<7.2                              |      |        |        |        |        |        |        |        |           |
| 7.20-<7.25                             |      |        | 6      |        | 3      |        | 2      |        |           |
| 7.25-<7.30                             | 9    |        |        |        |        |        |        |        |           |
| 7.30-<7.35                             |      |        |        |        |        | 1      |        |        |           |
| 7.35-<7.40                             |      |        | 0      |        |        |        |        |        |           |
| 7.40-<7.45                             | 5    |        |        |        |        | 1      |        |        |           |
| 7.45-<7.50                             |      | 0      |        | 2      |        |        |        |        |           |
| 7.50-<7.55                             |      |        |        |        |        |        |        |        |           |
| 7.55-<7.60                             |      | 3      |        |        |        | 12     |        |        |           |
| 7.60-<7.65                             | 0    |        |        |        |        |        |        |        |           |
| $\geq 7.65$                            |      |        |        |        |        |        |        |        |           |



# APACHE III

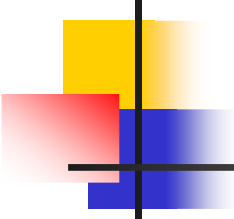
| <b>Age (years)</b> |    |
|--------------------|----|
| $\leq 44$          | 0  |
| 45-59              | 5  |
| 60-64              | 11 |
| 65-69              | 13 |
| 70-74              | 16 |
| 75-85              | 17 |
| $\geq 85$          | 24 |



# APACHE III

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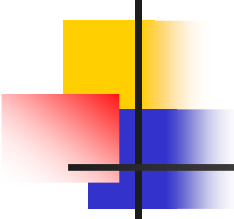
| <b>Chronic health evaluation (Comorbid condition)</b> |    |
|-------------------------------------------------------|----|
| AIDS                                                  | 23 |
| Hepatic failure                                       | 16 |
| Lymphoma                                              | 13 |
| Metastatic cancer                                     | 11 |
| Leukemia/multiple myeloma                             | 10 |
| Immunosuppression                                     | 10 |
| Cirrhosis                                             | 4  |



# APACHE III

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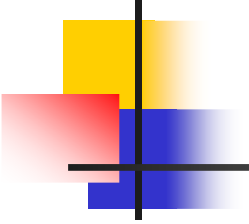
- Predictive equations
  - 1988 - 1990 (17,440) (version H)
  - 1993 – 1996 (>37,000) (version I)
- 66 specific diagnosis and 12 organ-system related categories
- ICU re-admission
- Emergency surgery
- Location prior to ICU admission
- Hospital LOS and location prior to ICU admission



# APACHE III

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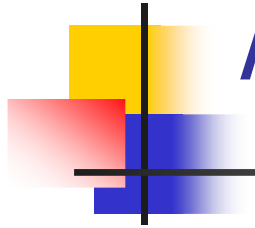
- Hospital mortality
- Intensive care resource use
  - ICU/hospital LOS
  - Risk of active life supporting therapy
  - Frequency of lab testing
  - Duration of mechanical ventilation



# APACHE III

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- Prognosis of individual patient
- Hospital mortality is updated daily
  - Day 1 score
  - Physiological status during the current day
  - Physiological trends in previous 24 hours



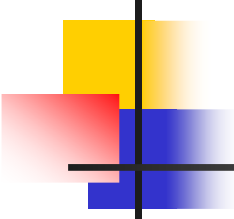
# APACHE III

---

- Expensive





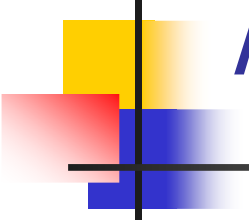


# APACHE IV

Zimmerman JE et al, Crit Care Med 2006, 34:1297

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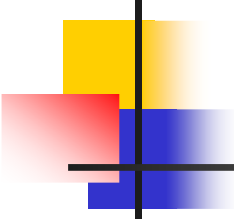
- Published in 2006
- 2002 – 2003 (131,618 ICU admissions)
- 104 ICUs in 45 US hospitals



# APACHE IV

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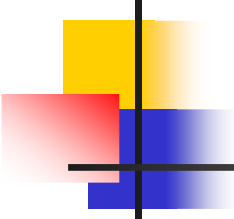
- Age
  - continuous measure + 5 spline terms
- APS
  - ~ APACHE III + 5 spline terms
- Comorbidities
  - ~ APACHE III (not for elective surgery patients)
- ICU admission diagnosis
  - 116 categories (vs 78 in APACHE III & 50 in APACHE II)



# APACHE IV

---

- ICU admission source
  - Floor, A&ED, OT, HDU, direct admission, other ICU, other hospital, others
- LOS before ICU admission
  - Square root + 4 spline terms
- Emergency OT
- Unable to assess GCS
- Thrombolytic therapy for AMI
- Mechanical ventilation
- Rescaled GCS (15 - GCS)
- PaO<sub>2</sub>/FiO<sub>2</sub> ratio



# APACHE IV

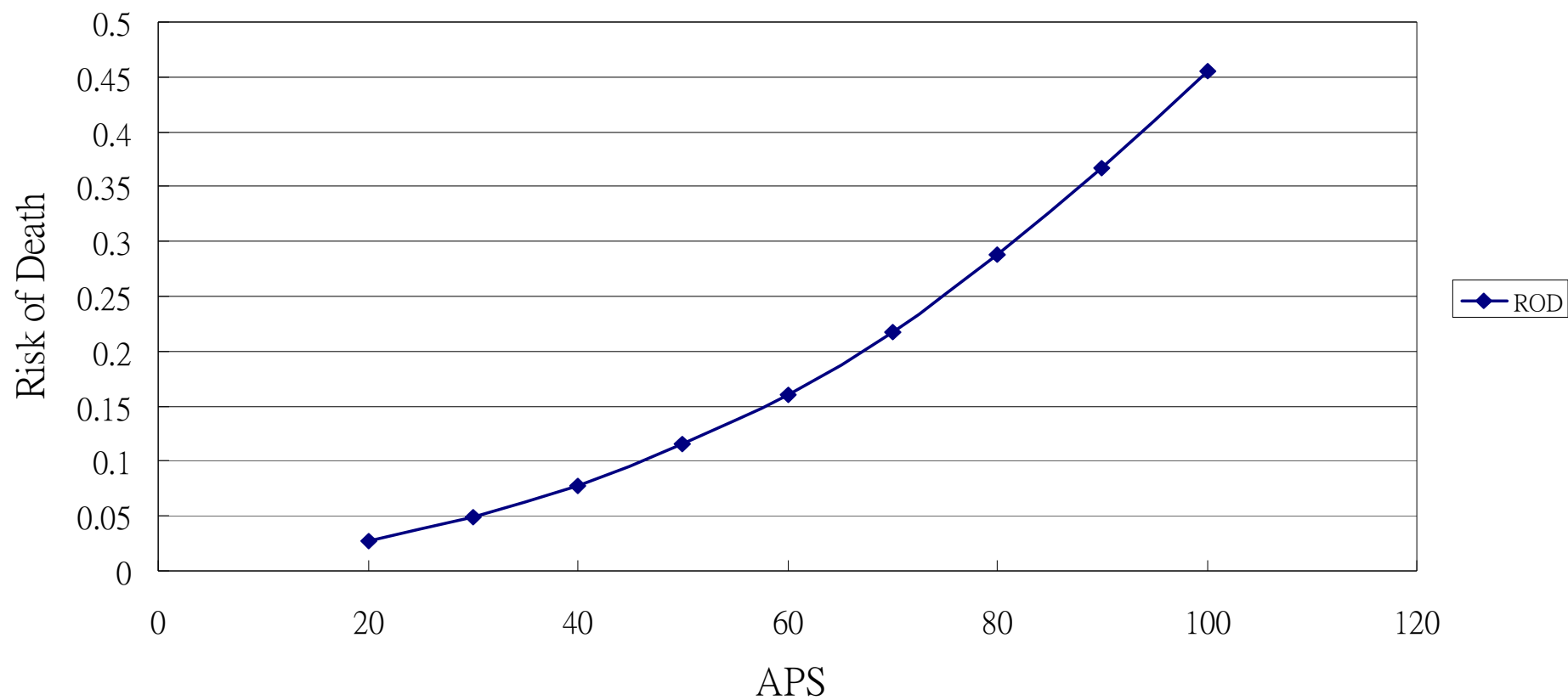
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- Spline terms for age, APS and prior LOS
  - Allow for nonlinear relationships with outcomes
  - Replace  $\text{logit}(\text{odds}) = b_0 + b_1x_1 + b_2x_2 + \dots$
- [www.criticaloutcomes.cerner.com](http://www.criticaloutcomes.cerner.com)
- Discrimination
  - Area under ROC
- Calibration
  - Cox chi-square test
  - Hosmer-Lemeshow C statistic



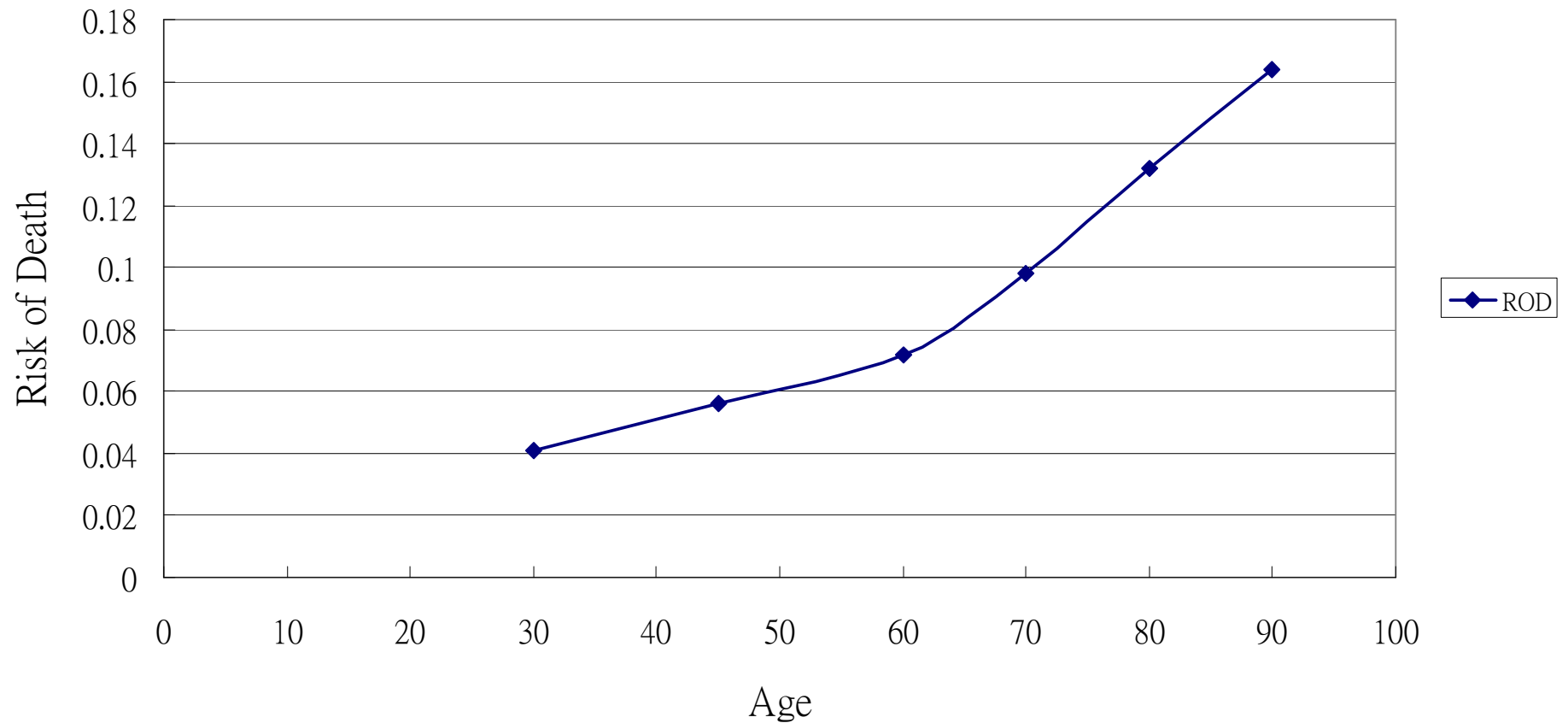
# APACHE IV

## Risk of Death with APS



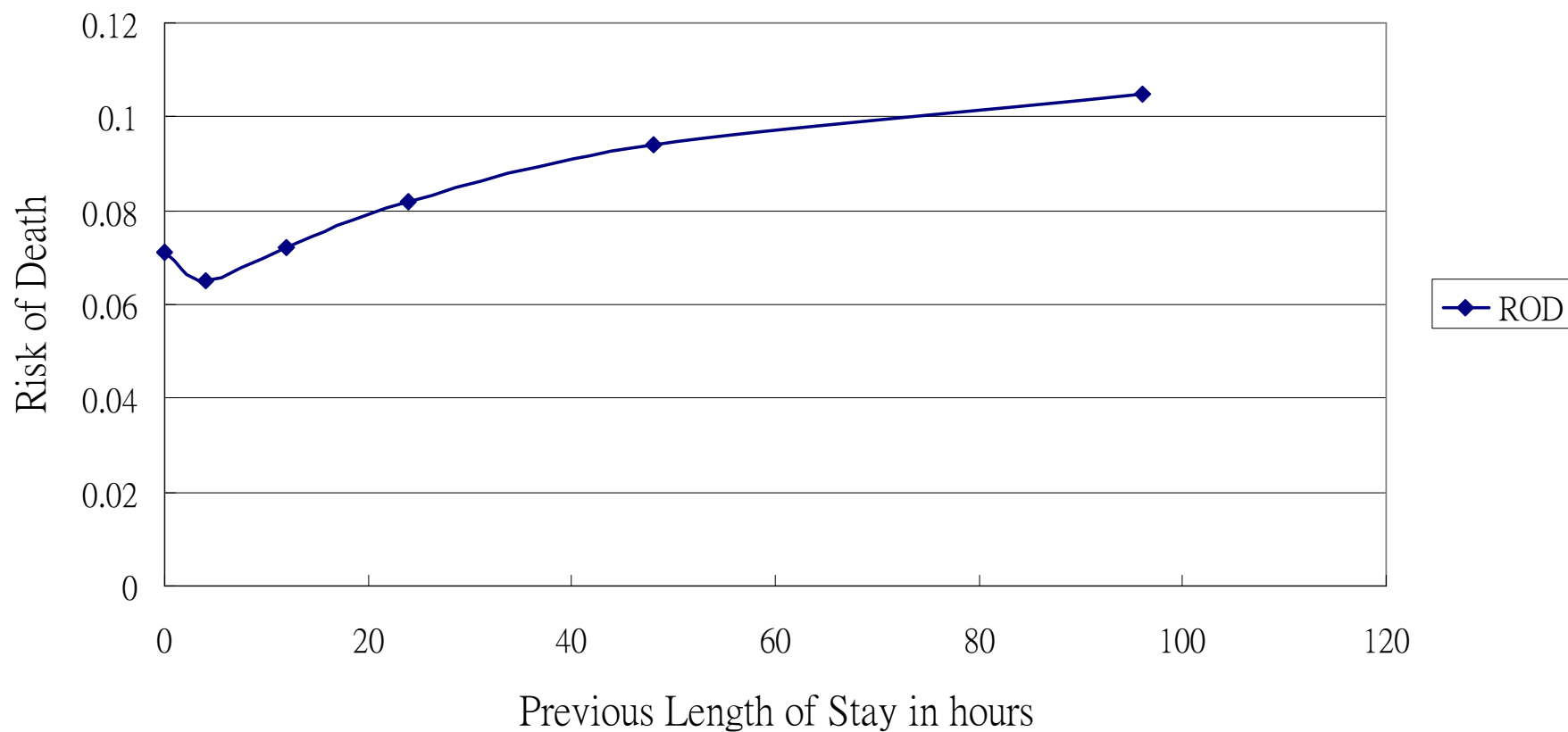
# APACHE IV

Risk of Death with Age



# APACHE IV

## Risk of Death with Previous LOS



# APACHE IV

**Table 4.** Comparison of discrimination and calibration of the Acute Physiology and Chronic Health Evaluation (APACHE) IV mortality model and earlier APACHE III versions when applied to the same 2002–2003 validation data set (n = 44,288)

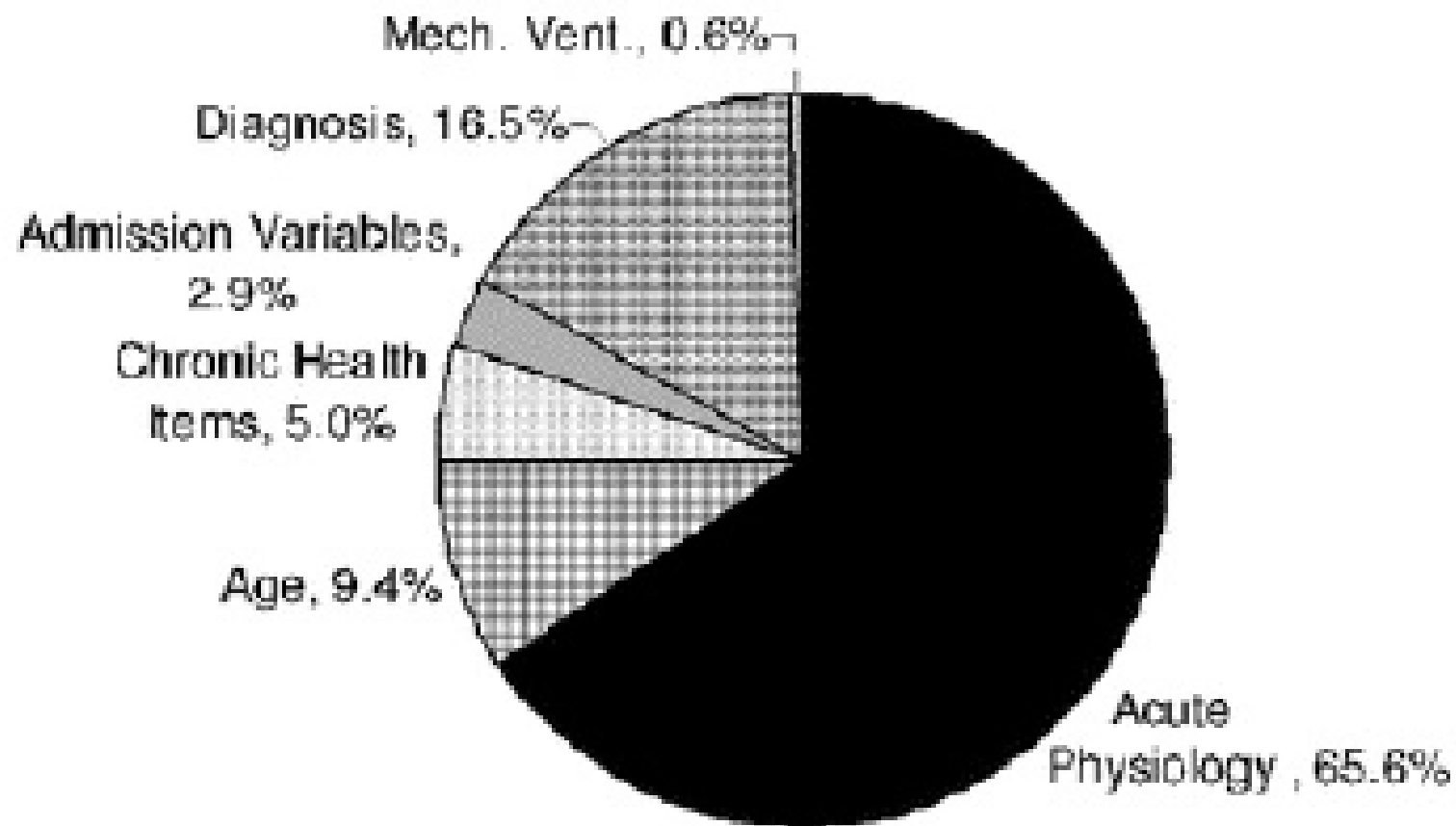
| Version                     | APACHE IV <sup>a</sup> | APACHE III—<br>Version I <sup>b</sup> | APACHE III—<br>Version H <sup>c</sup> |
|-----------------------------|------------------------|---------------------------------------|---------------------------------------|
| Observed mortality rate, %  | 13.51                  | 13.51                                 | 13.51                                 |
| Predicted mortality rate, % | 13.55                  | 14.64                                 | 16.90                                 |
| SMR, observed/predicted     | 0.997 ( $p = .79$ )    | 0.923 ( $p < .001$ )                  | 0.799 ( $p < .001$ )                  |
| Area under the ROC curve    | 0.880                  | 0.870                                 | 0.868                                 |
| Hosmer-Lemeshow $\chi^2$    | 16.8 ( $p = .08$ )     | 124.6 ( $p < .001$ )                  | 635.4 ( $p < .001$ )                  |

ROC, receiver operating characteristic curve.

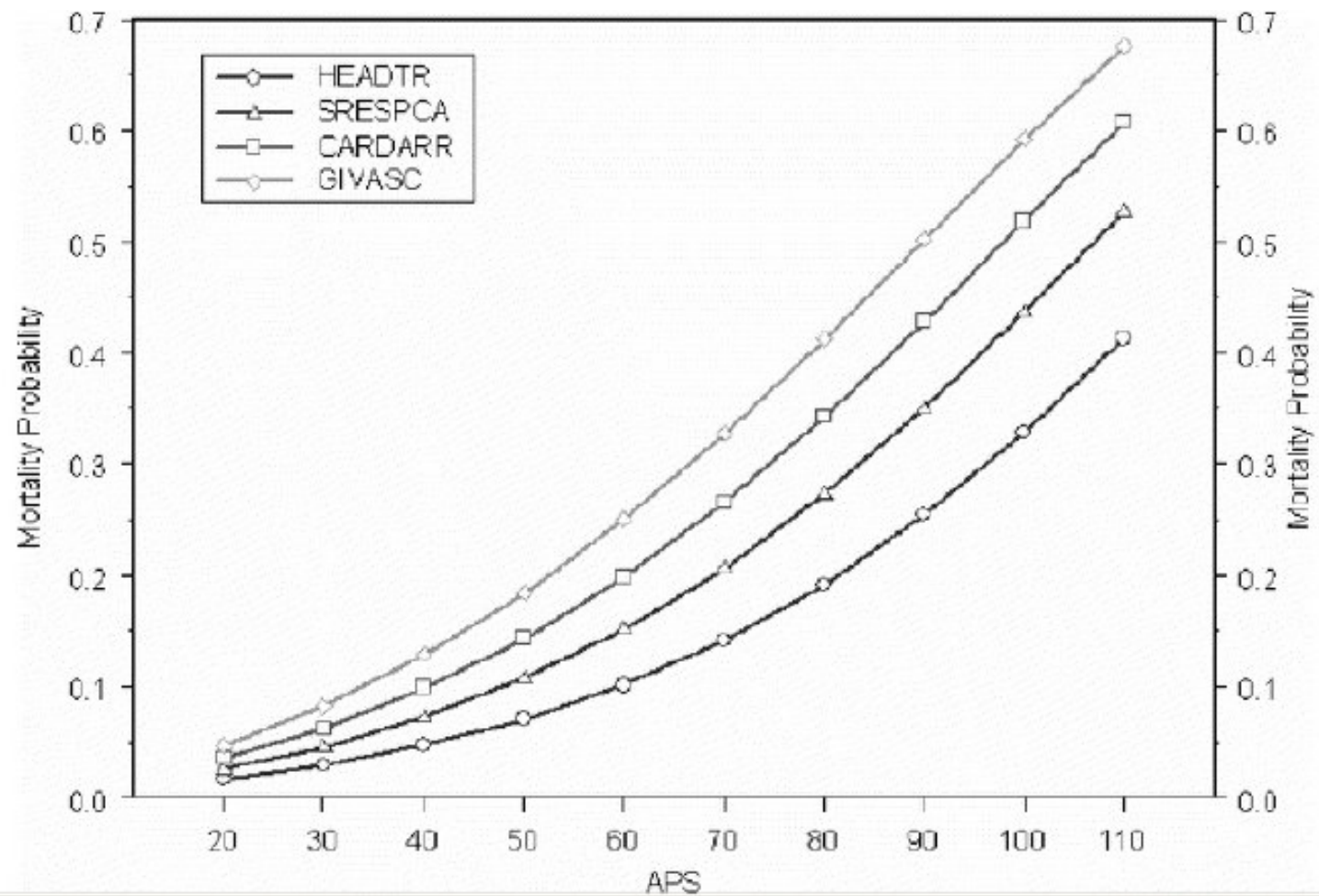
<sup>a</sup>APACHE IV was validated using data for 44,288 admissions to 104 intensive care units during 2002 and 2003; <sup>b</sup>APACHE III version I was developed using data for 40,264 admissions to 188 intensive care units during 1993 and 1996 (unpublished data); <sup>c</sup>APACHE III version H was developed using data for 16,662 admissions to 42 intensive care units during 1988 and 1989 (Refs. 2, 23).



# APACHE IV



# APACHE IV



# APACHE IV

**Table 7.** Standardized mortality ratio for selected disease groups when Acute Physiology and Chronic Health Evaluation (APACHE) IV, APACHE III version I, and APACHE III version H predictions are used for the 2002–2003 validation data set (n = 44,288)

| Disease Group                        | No.   | Observed<br>Mortality, % | APACHE IV <sup>a</sup>    |      | APACHE III Version I <sup>b</sup> |                   | APACHE III Version H <sup>c</sup> |                   |
|--------------------------------------|-------|--------------------------|---------------------------|------|-----------------------------------|-------------------|-----------------------------------|-------------------|
|                                      |       |                          | Predicted<br>Mortality, % | SMR  | Predicted<br>Mortality, %         | SMR               | Predicted<br>Mortality, %         | SMR               |
| Sepsis (nonurinary tract)            | 1,821 | 37.3                     | 37.4                      | 1.00 | 41.8                              | 0.89 <sup>d</sup> | 45.2                              | 0.83 <sup>d</sup> |
| Cardiac arrest                       | 872   | 58.3                     | 58.4                      | 1.00 | 53.1                              | 1.10 <sup>d</sup> | 54.5                              | 1.07 <sup>e</sup> |
| Emphysema/bronchitis                 | 878   | 15.1                     | 13.4                      | 1.13 | 17.4                              | 0.87              | 19.8                              | 0.76 <sup>d</sup> |
| Noncardiac pulmonary<br>edema (ARDS) | 310   | 27.7                     | 28.2                      | 0.98 | 36.3                              | 0.76 <sup>d</sup> | 34.0                              | 0.82 <sup>e</sup> |
| Thoractomy for lung<br>neoplasm      | 633   | 4.1                      | 4.3                       | 0.96 | 3.5                               | 1.16              | 5.2                               | 0.80              |
| Aortic aneurysm, elective<br>repair  | 701   | 5.6                      | 4.7                       | 1.19 | 3.9                               | 1.41              | 4.6                               | 1.20              |
| Stroke                               | 860   | 21.5                     | 20.2                      | 1.06 | 19.8                              | 1.09              | 22.6                              | 0.95              |
| Hepatic failure                      | 236   | 45.8                     | 41.4                      | 1.11 | 47.4                              | 0.97              | 59.3                              | 0.77 <sup>d</sup> |
| Respiratory arrest                   | 490   | 34.1                     | 32.2                      | 1.06 | 35.3                              | 0.97              | 37.4                              | 0.91              |

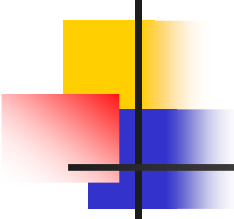
SMR, standardized mortality ratio; ARDS, acute respiratory distress syndrome.

<sup>a</sup>APACHE IV was validated using data for 44,288 admissions to 104 intensive care units during 2002 and 2003; <sup>b</sup>APACHE III version I was developed using data for 40,264 admissions to 188 intensive care units during 1993 and 1996 (unpublished data); <sup>c</sup>APACHE III version H was developed using data for 1,662 admissions to 42 intensive care units during 1988 and 1989 (Refs. 2, 23); <sup>d</sup> $p < .001$ ; <sup>e</sup> $p < .01$ .



# SAPS II

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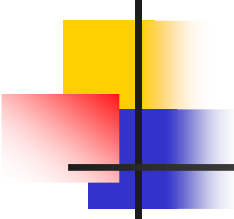


# SAPS II

Legall JR et al, JAMA 1993, 270:2957 - 2963

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- 1991 – 1992
- 12,997 patients
- Europe & North America ICUs



# SAPS II

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- Simple
- 12 physiological variables
  - no venous/arterial blood gases needed
- Age
- Types of admission
  - scheduled OT, unscheduled OT, medical
- Chronic diseases
  - AIDS, metastatic cancer & haematologic malignancy
- No disease category needed



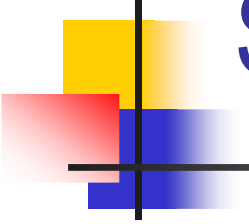
# SAPS II

| Variable/Points                                                                                                                      | 26  | 13  | 12   | 11              | 9                    | 7    | 6               | 5     | 4           | 3     | 2      | 0                  | 1    | 2 | 3               | 4                       | 6                      | 7     | 8                    | 9                 | 10               | 12    | 15    | 16    | 17   | 18  |
|--------------------------------------------------------------------------------------------------------------------------------------|-----|-----|------|-----------------|----------------------|------|-----------------|-------|-------------|-------|--------|--------------------|------|---|-----------------|-------------------------|------------------------|-------|----------------------|-------------------|------------------|-------|-------|-------|------|-----|
| Age (years)                                                                                                                          |     |     |      |                 |                      |      |                 |       |             |       |        | <40                |      |   |                 |                         |                        | 40-59 |                      |                   |                  | 60-69 | 70-74 | 75-79 |      | ≥80 |
| Heart rate (beats/min)                                                                                                               |     |     |      | <40             |                      |      |                 |       |             | 40-69 | 70-119 |                    |      |   |                 | 120-159                 |                        | ≥160  |                      |                   |                  |       |       |       |      |     |
| Systolic BP (mmHg)                                                                                                                   | <70 |     |      |                 |                      |      |                 | 70-99 |             |       |        | 100-199            | ≥200 |   |                 |                         |                        |       |                      |                   |                  |       |       |       |      |     |
| Body temperature (°C)<br>(°F)                                                                                                        |     |     |      |                 |                      |      |                 |       |             |       |        | < 39<br>< 102.2    |      |   | ≥ 39<br>≥ 102.2 |                         |                        |       |                      |                   |                  |       |       |       |      |     |
| Only if VENT or CPAP:<br>Paco <sub>2</sub> (mmHg)/<br>Fio <sub>2</sub> (0.XX)<br>Paco <sub>2</sub> (kPa)/<br>Fio <sub>2</sub> (0.XX) |     |     |      | < 100<br>< 13.3 | 100-199<br>13.3-26.5 |      | ≥ 200<br>≥ 26.6 |       |             |       |        |                    |      |   |                 |                         |                        |       |                      |                   |                  |       |       |       |      |     |
| Urinary output (l/day)                                                                                                               |     |     |      | <0.500          |                      |      |                 |       | 0.500-0.999 |       |        | ≥ 1.000            |      |   |                 |                         |                        |       |                      |                   |                  |       |       |       |      |     |
| Blood urea (mmol/l)<br>(g/l)                                                                                                         |     |     |      |                 |                      |      |                 |       |             |       |        | < 10.0<br>< 0.60   |      |   |                 |                         | 10.0-29.9<br>0.60-1.79 |       |                      |                   | ≥ 30.0<br>≥ 1.80 |       |       |       |      |     |
| WBC (10 <sup>3</sup> /mm <sup>3</sup> )                                                                                              |     |     | <1.0 |                 |                      |      |                 |       |             |       |        | 1.0-19.9           |      |   | ≥ 20.0          |                         |                        |       |                      |                   |                  |       |       |       |      |     |
| Serum K (mmol/l)                                                                                                                     |     |     |      |                 |                      |      |                 |       |             | <3.0  |        | 3.0-4.9            |      |   | ≥ 5.0           |                         |                        |       |                      |                   |                  |       |       |       |      |     |
| Serum Na (mmol/l)                                                                                                                    |     |     |      |                 |                      |      |                 | < 125 |             |       |        | 125-144            | ≥145 |   |                 |                         |                        |       |                      |                   |                  |       |       |       |      |     |
| Serum HCO <sub>3</sub> (mmol/l)                                                                                                      |     |     |      |                 |                      |      |                 | < 15  |             | 15-19 |        | ≥ 20               |      |   |                 |                         |                        |       |                      |                   |                  |       |       |       |      |     |
| Bilirubin (μmol/l)<br>(mg/l)                                                                                                         |     |     |      |                 |                      |      |                 |       |             |       |        | <68.4<br>< 4.0     |      |   |                 | 68.4-102.5<br>40.0-59.9 |                        |       |                      | ≥ 102.6<br>≥ 60.0 |                  |       |       |       |      |     |
| GCS                                                                                                                                  | <6  | 6-8 |      |                 |                      | 9-10 |                 | 11-13 |             |       |        | 14-15              |      |   |                 |                         |                        |       |                      |                   |                  |       |       |       |      |     |
| Chronic diseases                                                                                                                     |     |     |      |                 |                      |      |                 |       |             |       |        |                    |      |   |                 |                         |                        |       |                      | Met.can.          | Hem.mal.         |       |       |       | AIDS |     |
| Type of admission                                                                                                                    |     |     |      |                 |                      |      |                 |       |             |       |        | Sched-<br>surgical |      |   |                 |                         | Medical                |       | Unsched-<br>surgical |                   |                  |       |       |       |      |     |
| SUM OF POINTS                                                                                                                        |     |     |      |                 |                      |      |                 |       |             |       |        |                    |      |   |                 |                         |                        |       |                      |                   |                  |       |       |       |      |     |

TOTAL SAPS II pts  
RISK OF HOSPITAL DEATH %

**Fig. 1** SAPS II score sheet: BP, blood pressure; VENT, ventilated; CPAP, continuous positive airways pressure; WBC, white blood cells; GCS, Glasgow Coma Scale; Met. can., metastatic cancer; Hem. mal., hematological malignancy.





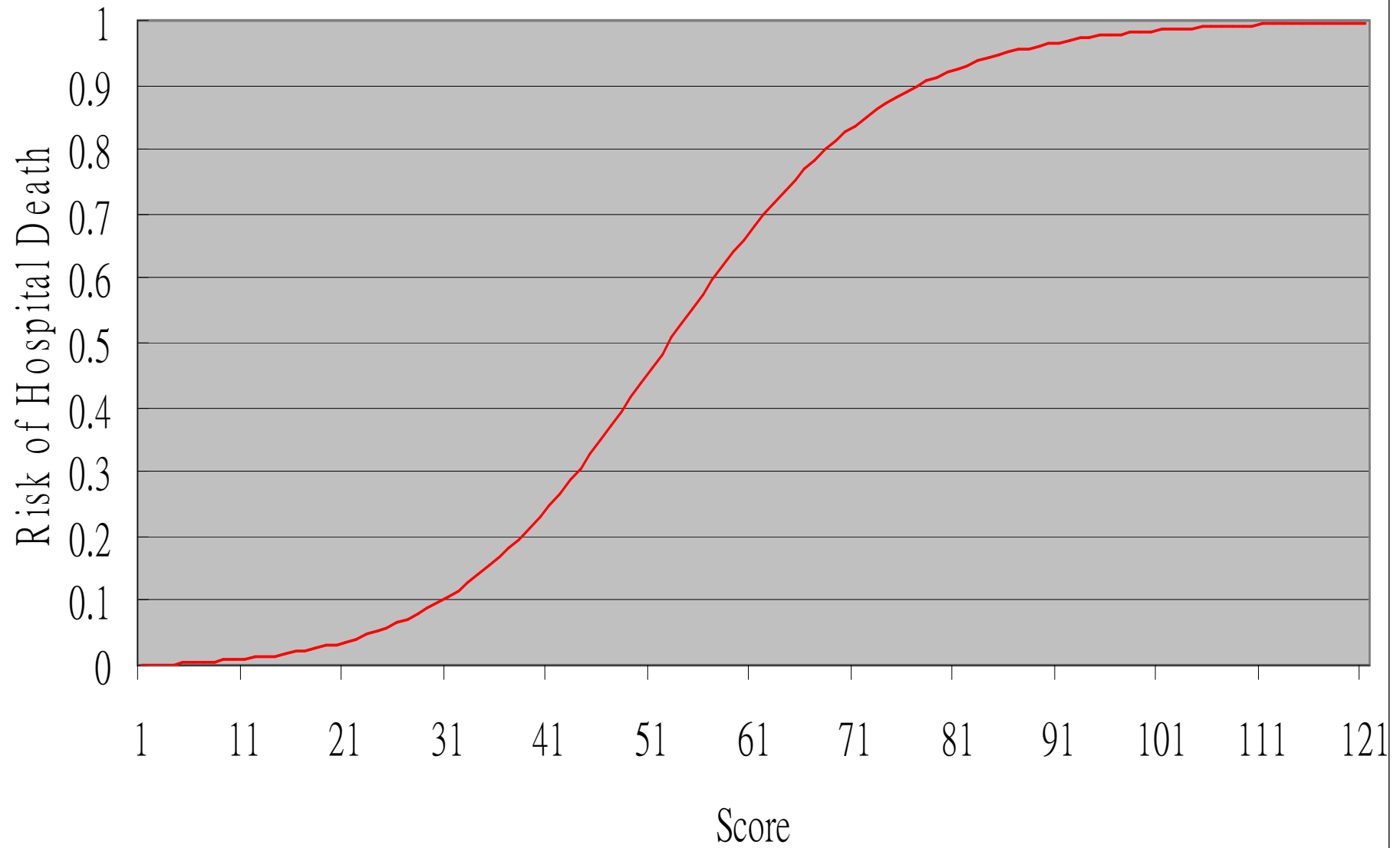
## SAPS II

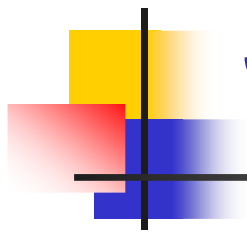
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- $\text{Logit} = b_0 + b_1 * \text{score} + b_2 * [\ln(\text{score} + 1)]$ 
  - $b_0 = -7.7631$
  - $b_1 = 0.0737$
  - $b_2 = 0.9972$
  
- $\text{ROD} = e^{\text{logit}} / (1 + e^{\text{logit}})$



## SAPS II scoring system





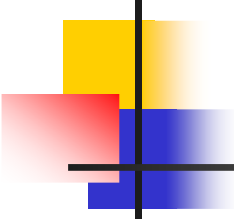
# SAPS 3

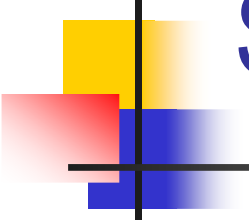
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# SAPS 3

Moreno RP et al, Intensive Care Med 2005, 31:1336

[www.saps3.org](http://www.saps3.org)

- 
- 
- October to December 2002
  - 303 ICUs all over the world
  - 16,784 patients
  - ICU admission data ( $\pm$  1 hour)
  - ~80% for model development
  - ~20% for model validation



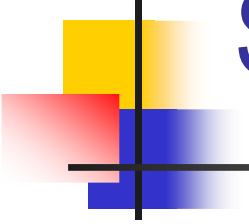
## SAPS 3

---

- 20 variables selected for the final model

50%

- Age
- Co-morbidities
- Use of vasoactive drugs before ICU admission
- Intrahospital location before ICU admission
- LOS in hospital before ICU admission

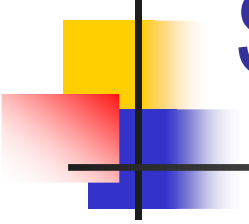


## SAPS 3

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22.5%

- Reasons for ICU admission
- Surgical status at ICU admission
- Planned/unplanned ICU admission
- Anatomical site of surgery
- Presence of infection at ICU admission & place acquired



## SAPS 3

---

27.5%

- Lowest estimated GCS
- Highest heart rate
- Lowest systolic BP
- Highest bilirubin
- Highest body temp
- Highest creatinine
- Highest leucocytes
- Lowest platelets
- Lowest pH
- Ventilatory support & PaO<sub>2</sub>

# SAPS 3

**Table 1** SAPS 3 admission scoresheet—Part 1

| Box I                                                   | 0                                   | 3                            | 5              | 6                                                                         | 7         | 8                                | 9                        | 11                        | 13      | 15                | 18   |
|---------------------------------------------------------|-------------------------------------|------------------------------|----------------|---------------------------------------------------------------------------|-----------|----------------------------------|--------------------------|---------------------------|---------|-------------------|------|
| Age, years                                              | <40                                 |                              | >=40<60        |                                                                           |           |                                  | >=60<70                  |                           | >=70<75 | >=75<80           | >=80 |
| Co-Morbidities                                          |                                     | Cancer therapy <sup>2)</sup> |                | Chron. HF (NYHA IV),<br>Haematological cancer <sup>3),4)</sup><br>>=14<28 | >=28      | Cirrhosis,<br>AIDS <sup>3)</sup> |                          | Cancer <sup>5)</sup>      |         |                   |      |
| Length of stay before ICU admission, days <sup>1)</sup> | <14                                 |                              |                |                                                                           |           |                                  |                          |                           |         |                   |      |
| Intra-hospital location before ICU admission            |                                     |                              | Emergency room |                                                                           | Other ICU | Other <sup>6)</sup>              |                          |                           |         |                   |      |
| Use of major therapeutic options before ICU admission   |                                     | Vasoactive drugs             |                |                                                                           |           |                                  |                          |                           |         |                   |      |
| Box II                                                  | 0                                   | 3                            | 4              | 5                                                                         | 6         |                                  |                          |                           |         |                   |      |
| ICU admission:<br>Planned or Unplanned                  |                                     |                              |                |                                                                           |           | Unplanned                        |                          |                           |         |                   |      |
| Reason(s) for ICU admission                             | please see Part 2 of the scoresheet |                              |                |                                                                           |           |                                  |                          |                           |         |                   |      |
| Surgical status at ICU admission                        |                                     |                              |                | Scheduled surgery                                                         |           |                                  |                          | No surgery <sup>7)</sup>  |         | Emergency surgery |      |
| Anatomical site of surgery                              | please see Part 2 of the scoresheet |                              |                |                                                                           |           |                                  |                          |                           |         |                   |      |
| Acute infection at ICU admission                        |                                     |                              |                |                                                                           |           |                                  | Nosocomial <sup>8)</sup> | Respiratory <sup>9)</sup> |         |                   |      |

# SAPS 3

Table 1 continued

| Box III                                       | 15  | 13  | 11  | 10                              | 8       | 7                               | 5                       | 3        | 2    | 0                         | 2             | 4      | 5       | 7       | 8       |
|-----------------------------------------------|-----|-----|-----|---------------------------------|---------|---------------------------------|-------------------------|----------|------|---------------------------|---------------|--------|---------|---------|---------|
| Estimated Glasgow Coma Scale (lowest), points | 3-4 |     |     | 5                               |         | 6                               |                         |          | 7-12 | >=13                      |               |        |         |         |         |
| Total bilirubine (highest), mg/dL             |     |     |     |                                 |         |                                 |                         |          |      | <2                        |               | >=2<6  | >=6     |         |         |
| Total bilirubine (highest), μmol/L            |     |     |     |                                 |         |                                 |                         |          |      | <34.2                     |               | >=34.2 | >=102.6 |         |         |
| Body temperature (highest), Degrees Celsius   |     |     |     |                                 |         | <35                             |                         |          |      | >=35                      |               | <102.6 |         |         |         |
| Creatinine (highest), mg/dL                   |     |     |     |                                 |         |                                 |                         |          |      | <1.2                      | >=1.2<2       |        |         | >=2<3.5 | >=3.5   |
| Creatinine (highest), μmol/L                  |     |     |     |                                 |         |                                 |                         |          |      | <106.1                    | >=106.1<176.8 |        |         | >=176.8 | >=309.4 |
| Heart rate (highest), beats/minute            |     |     |     |                                 |         |                                 |                         |          |      | <120                      |               |        | >=120   | >=160   |         |
| Leukocytes (highest), G/L                     |     |     |     |                                 |         |                                 |                         |          |      |                           |               |        | <160    |         |         |
| Hydrogen ion concentration (lowest), pH       |     |     |     |                                 |         |                                 |                         | <=7.25   |      | >7.25                     | >=15          |        |         |         |         |
| Plateletes (lowest), G/L                      |     | <20 |     |                                 | >=20<50 |                                 | >=50<100                |          |      |                           |               |        |         |         |         |
| Systolic blood pressure (lowest), mm Hg       |     |     | <40 |                                 | >=40<70 |                                 |                         | >=70<120 |      |                           |               |        |         |         |         |
| Oxygenation <sup>10), 11)</sup>               |     |     |     | PaO2/<br>FiO2<br><100<br>and MV |         | PaO2/<br>FiO2<br>=100<br>and MV | PaO2<60<br>and no<br>MV |          |      | PaO2><br>=60 and<br>no MV |               |        |         |         |         |

The definition for all variables can be found in detail in Appendix C of the ESM. For names and abbreviations which are differing from those in the ESM, explanations are given below. Generally, it should be noted that no mutually exclusive conditions exist for the following fields: Comorbidities, Reasons for ICU admission, and Acute infection at ICU admission. Thus, if a patient has more than one condition listed for a specific variable, points are assigned for all applicable combinations.

<sup>1</sup> This variable is calculated from the two data fields: ICU Admission date and time—Hospital admission date and time (see Appendix C of the ESM).

<sup>2</sup> Cancer Therapy refers to the data definitions in Appendix C of the ESM: Co-Morbidities: Chemotherapy, Immunosuppression other, Radiotherapy, Steroid treatment

<sup>3</sup> If a patient has both conditions he/she gets double points.

<sup>4</sup> Chronic HF (NYHA IV)/Haematological cancer refer both to the data definitions in Appendix C of the ESM: Co-Morbidities: Chronic heart failure class IV NYHA, Haematological cancer.

<sup>5</sup> Cancer refers to the data definitions in Appendix C of the ESM: Co-Morbidities: Metastatic cancer.

<sup>6</sup> Other refers to the data definitions in Appendix C of the ESM: Intra-hospital location before ICU admission: Ward, Other.

<sup>7</sup> No surgery refers to the data definitions in Appendix C of the ESM: Surgical Status at ICU Admission: Patient not submitted to surgery.

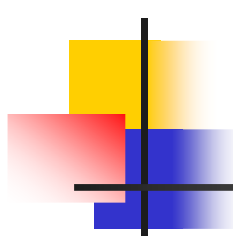
<sup>8</sup> Nosocomial refers to the data definitions in Appendix C of the ESM: Acute infection at ICU admission—Acquisition: Hospital-acquired.

<sup>9</sup> Respiratory refers to the data definition in Appendix C of the ESM: Acute infection at ICU admission—Site: Lower respiratory tract: Pneumonia, Lung abscess, other.

<sup>10</sup> PaO<sub>2</sub>, FiO<sub>2</sub> refer to the data definitions in Appendix C of the ESM: Arterial oxygen partial pressure (lowest), Inspiratory oxygen concentration.

<sup>11</sup> MV refers to the data definition in Appendix C of the ESM: Ventilatory support and mechanical ventilation.



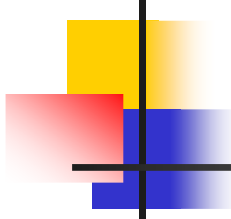


# SAPS 3

| Admission Scoresheet                                                                                                               |    |
|------------------------------------------------------------------------------------------------------------------------------------|----|
| ICU admission <sup>(1)</sup>                                                                                                       | 16 |
| Reason(s) for ICU admission                                                                                                        |    |
| Cardiovascular: Rhythm disturbance <sup>(2)</sup>                                                                                  | -5 |
| Neurologic: Seizures <sup>(2)</sup>                                                                                                | -4 |
| Cardiovascular: Hypovolemic hemorrhagic shock, Hypovolemic non hemorrhagic shock. / Digestive: acute abdomen, Other <sup>(2)</sup> | 3  |
| Neurologic: Coma, Stupor, Obtunded patient, Vigilance disturbances, Confusion, Agitation, Delirium                                 | 4  |
| Cardiovascular: septic shock. / Cardiovascular: Anaphylactic shock, mixed and undefined shock                                      | 5  |
| Hepatic: Liver failure                                                                                                             | 6  |
| Neurologic: focal neurologic deficit                                                                                               | 7  |
| Digestive: severe pancreatitis                                                                                                     | 9  |
| Neurologic: Intracranial mass effect                                                                                               | 10 |
| All others                                                                                                                         | 0  |

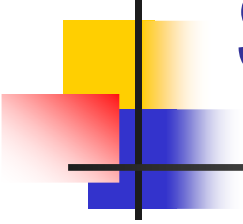
(1) Every patient gets an offset of 16 points for being admitted (to avoid negative SAPS 3 Scores).

(2) If both reasons for admission are present, only the worse value (-4) is scored.



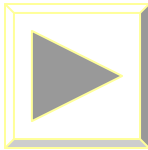
# SAPS 3

|                                                                                              |     |
|----------------------------------------------------------------------------------------------|-----|
| Admission Scoresheet                                                                         |     |
| <b>Anatomical site of surgery</b>                                                            |     |
| Transplantation surgery: Liver, Kidney, Pancreas, Kidney and pancreas, Transplantation other | -11 |
| Trauma – other, isolated: (includes Thorax, Abdomen, limb); Trauma – Multiple                | -8  |
| Cardiac surgery: CABG without valvular repair                                                | -6  |
| Neurosurgery: Cerebrovascular accident                                                       | 5   |
| All Other                                                                                    | 0   |

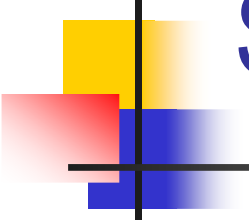


# SAPS 3

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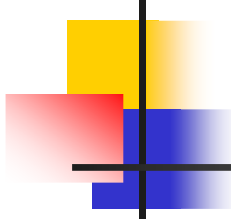
SAPS 3.excel



## SAPS 3

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- Total score      0 to 217
- $\text{Logit} = -32.6659 + \ln(\text{SAPS 3 score} + 20.5958) * 7.3068$
- $P = e^{\text{logit}} / (1 + e^{\text{logit}})$



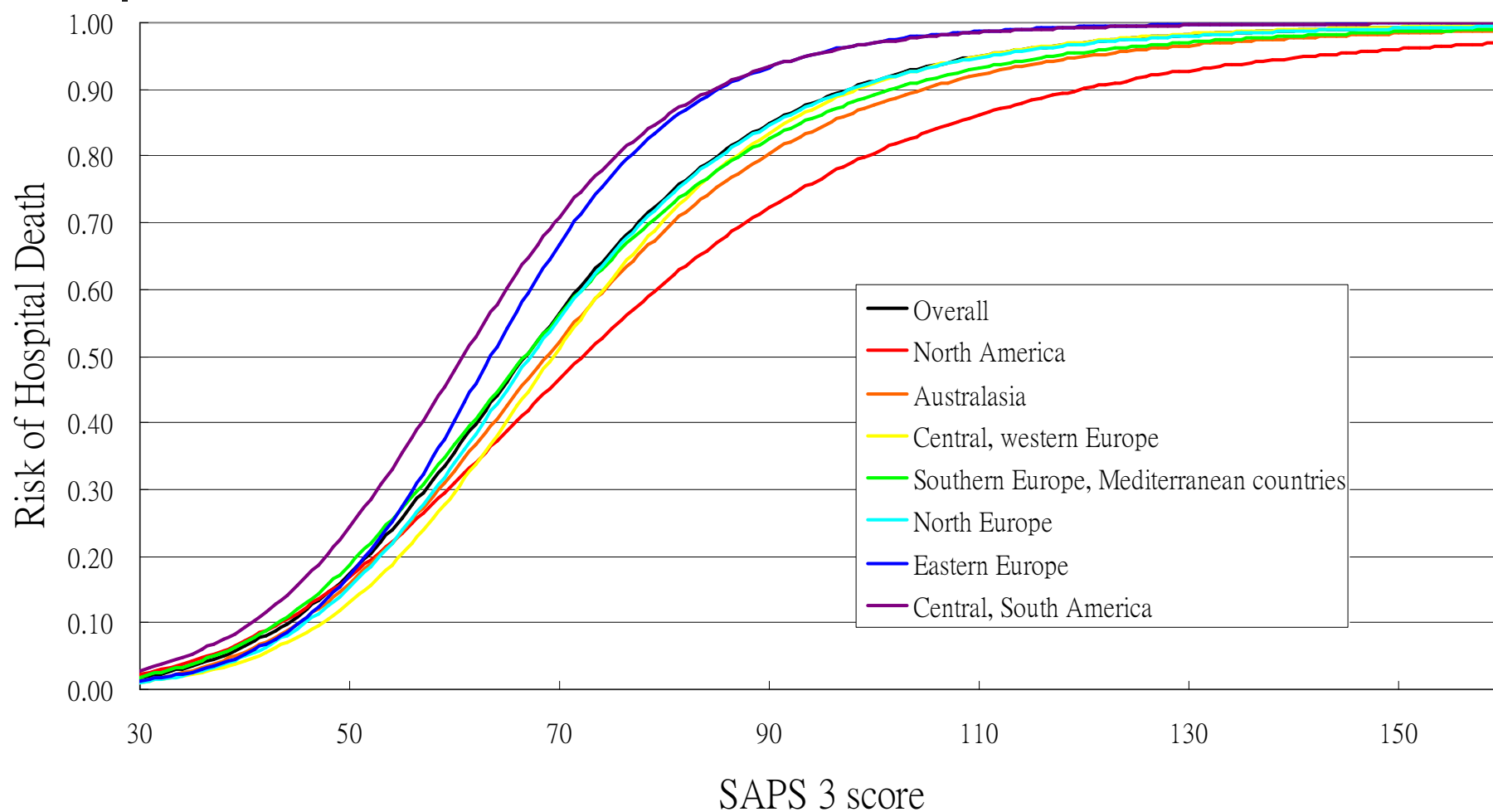
# SAPS 3

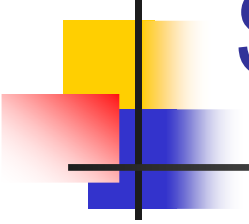
| Area                                     | Equation                                              | GOF $\hat{H}$ | $p$  | GOF $\hat{C}$ | $p$  | O/E  | CI        |
|------------------------------------------|-------------------------------------------------------|---------------|------|---------------|------|------|-----------|
| Australasia                              | Logit=-22.5717 + In (SAPS 3 score + 1 )<br>x5.3163    | 10.43         | 0.40 | 2.20          | 0.99 | 1.00 | 0.93-1.07 |
| Central, South America                   | Logit=-64.5990 + In (SAPS 3 score + 71.0599) x13.2322 | 8.94          | 0.54 | 7.03          | 0.72 | 1.00 | 0.94-1.06 |
| Central, Western Europe                  | Logit=-36.0877 + In (SAPS 3 score + 22.2655) x7.9867  | 15.13         | 0.13 | 12.15         | 0.27 | 1.00 | 0.94-1.06 |
| Eastern Europe                           | Logit=-60.1771 + In (SAPS 3 score + 51.4043) x12.6847 | 10.13         | 0.43 | 7.12          | 0.71 | 1.00 | 0.92-1.08 |
| North Europe                             | Logit=-26.9065 + In (SAPS 3 score + 5.5077) x6.2746   | 3.45          | 0.97 | 2.22          | 0.99 | 1.00 | 0.86-1.14 |
| Southern Europe, Mediterranean countries | Logit=-23.8501 + In (SAPS 3 score + 5.5708) x5.5709   | 5.28          | 0.87 | 13.12         | 0.22 | 1.00 | 0.97-1.03 |
| North America                            | Logit=-18.8839 + In (SAPS 3 score + 1) x4.3979        | 4.22          | 0.93 | 4.47          | 0.92 | 1.00 | 0.86-1.14 |

**GOF  $\hat{H}$**  : Hosmer-Lemeshow goodness-of-fit  $\hat{H}$  test; **GOF  $\hat{C}$** : Hosmer-Lemeshow goodness-of-fit  $\hat{C}$  test;  **$p$** : respective p-values; **O/E**: observed-to-expected mortality ratio; **CI**: 95% confidence interval.

# SAPS 3

SAPS 3





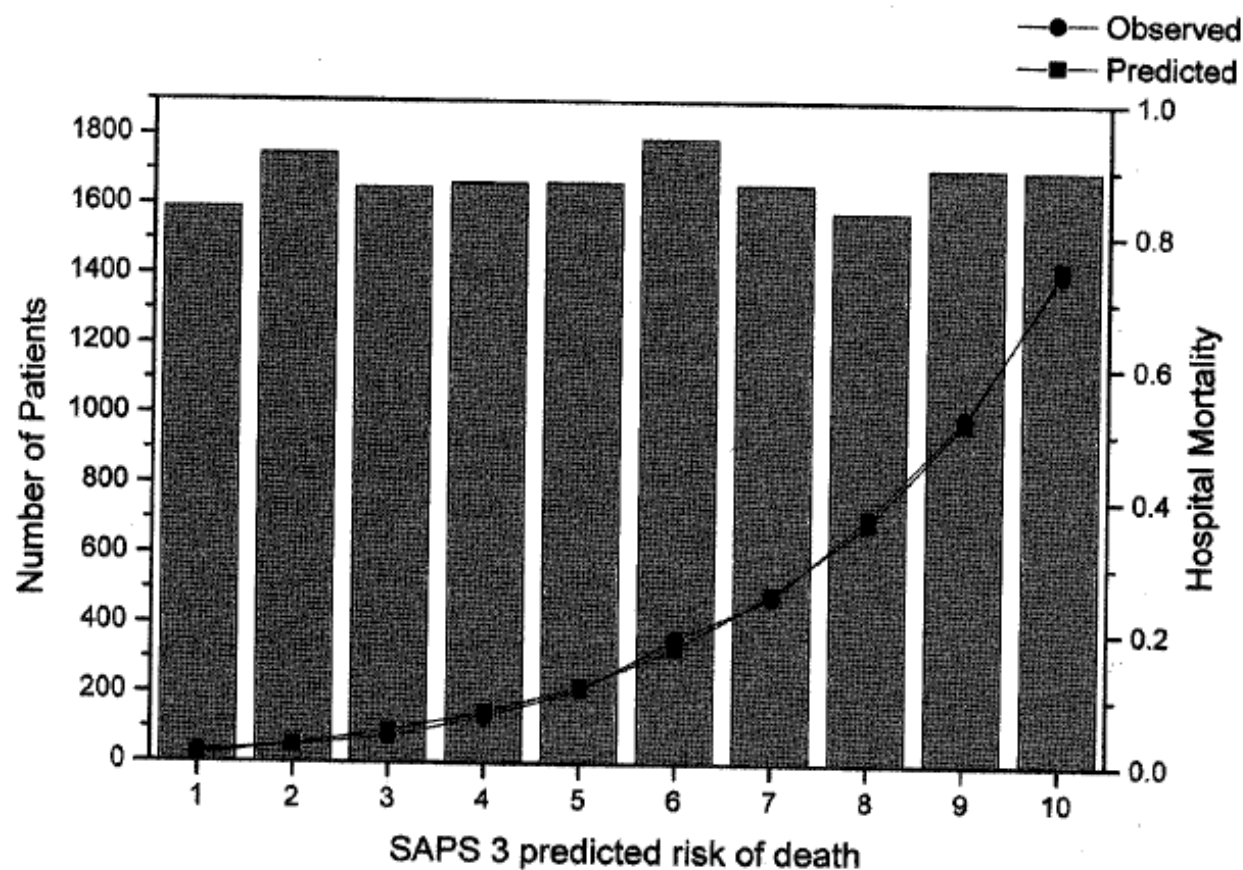
# SAPS 3

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- Good discrimination
  - Area under ROC curve 0.848
- Good calibration
  - H-L
    - $C = 14.29$ ,  $p=0.16$
    - $H = 10.56$ ,  $p=0.39$
- SAPS 3
  - Can predict hospital mortality

# SAPS 3

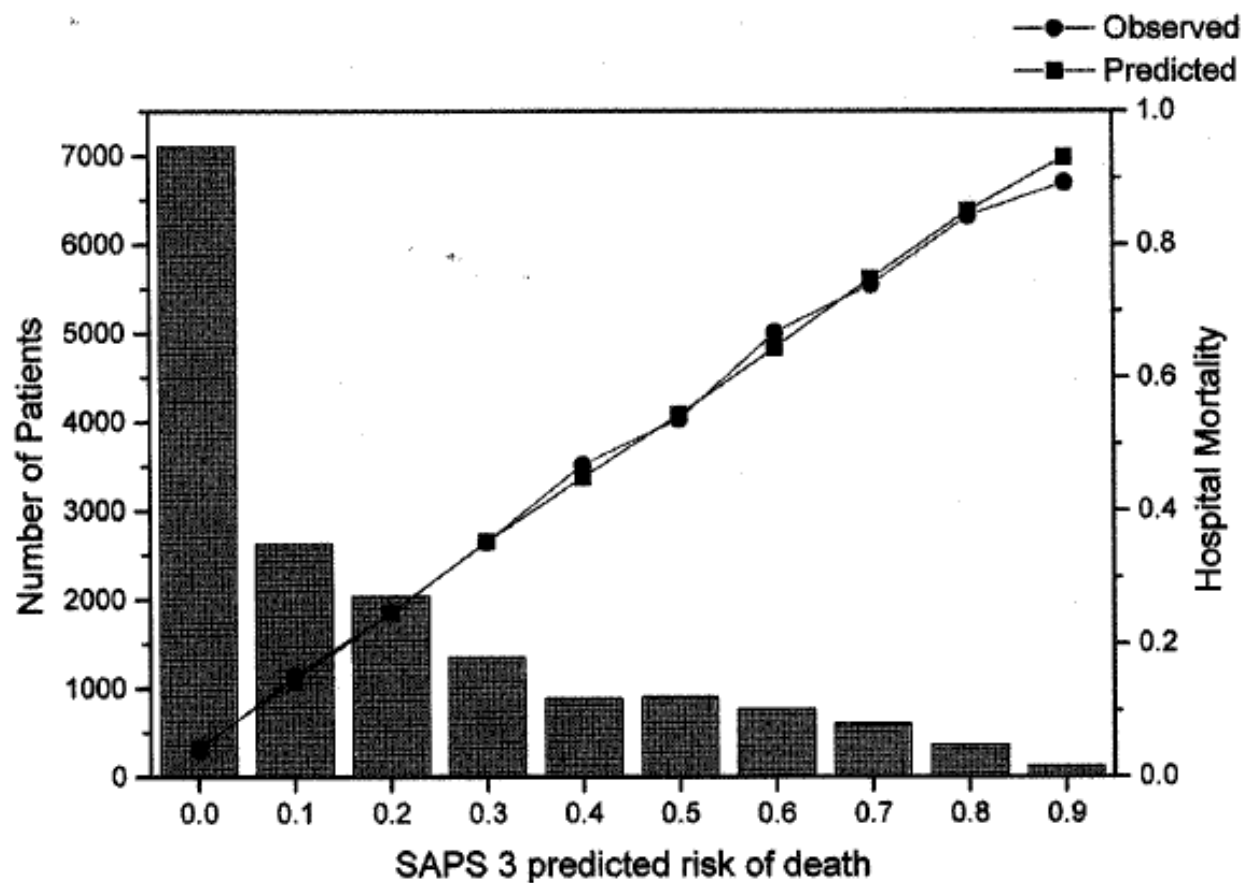
**Fig. 3** Hosmer-Lemeshow goodness-of-fit test  $\hat{C}$  in the overall sample. Predicted risk of hospital death, observed hospital mortality rate, and the corresponding number of patients per decile are shown. *Columns:* Number of patients; *squares:* mean SAPS 3-predicted mortality per decile; *circles:* mean observed mortality per decile

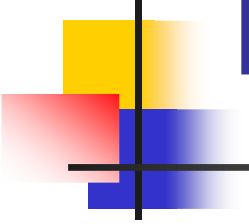




# SAPS 3

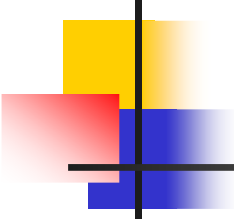
**Fig. 4** Hosmer-Lemeshow goodness-of-fit test  $\hat{H}$  in the overall sample. Predicted risk of hospital death, observed hospital mortality rate, and the corresponding number of patients per decile are shown. *Columns:* Number of patients; *squares:* mean SAPS 3-predicted mortality per decile; *circles:* mean observed mortality per decile





# Mortality Probability Model (MPM)

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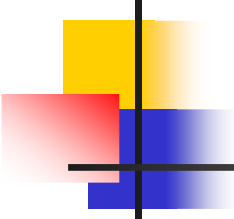


# Mortality Probability Model (MPM)

Lemeshow S et al, Crit Care Med 1985, 13:519 - 525

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- 1985 by Lemeshow et al.
- Entirely statistical derived
  - bottom up approach
  - 137 at admission & 75 at 24h reduced to
  - 7 at admission & 7 at 24h
- Coronary care, cardiac OT, burn and children <14 excluded
- Can collect values before admission & at 24h
- Variables more condition based
- Variables usually requiring 'yes' or 'no'



# MPM II

Lemeshow S et al, JAMA 1993, 270: 2478 - 2486

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- 1993 Lemeshow et al.
- 2 datasets
  - ~ 6,000 patients in US hospitals
  - ~ 14,000 patients in Europe & North America
- $MPM_0$  &  $MPM_{24}$



MPM<sub>0</sub>

- 15 variables on admission identified
- $\text{Logit} = b_0 + b_1x_1 + b_2x_2 + \dots + b_{15}x_{15}$
- $\text{ROD} = e^{\text{logit}} / (1 + e^{\text{logit}})$



---

|                               |         |
|-------------------------------|---------|
| ■ Coma or deep stupor         | 1.48592 |
| ■ Heart rate                  | 0.45603 |
| ■ Systolic BP                 | 1.06127 |
| ■ Chronic renal insufficiency | 0.91906 |
| ■ Cirrhosis                   | 1.13681 |
| ■ Metastatic neoplasm         | 1.19979 |
| ■ Acute renal failure         | 1.48210 |



MPM<sub>0</sub>

|                             |         |
|-----------------------------|---------|
| ■ Cardiac dysrhythmia       | 0.28095 |
| ■ Cerebrovascular incident  | 0.21338 |
| ■ Gastrointestinal bleeding | 0.39653 |
| ■ Intracranial mass effect  | 0.86533 |
| ■ Age (actual value)        | 0.03057 |
| ■ CPR prior to admission    | 0.56995 |
| ■ Mechanical ventilation    | 0.79105 |
| ■ Non-elective surgery      | 1.19098 |



## ■ Admission variables

|                            |         |
|----------------------------|---------|
| ■ Age                      | 0.03268 |
| ■ Cirrhosis                | 1.08745 |
| ■ Intracranial mass effect | 0.91314 |
| ■ Metastatic neoplasm      | 1.16109 |
| ■ Non-elective surgery     | 0.83404 |

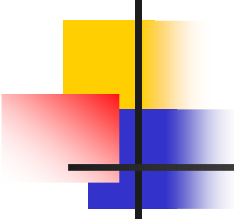




MPM<sub>24</sub>

## ■ Variables at 24h

|                           |         |
|---------------------------|---------|
| ■ Coma or deep stupor     | 1.68790 |
| ■ Mechanical ventilation  | 0.80845 |
| ■ Creatinine              | 0.72283 |
| ■ Confirmed infection     | 0.49742 |
| ■ PaO <sub>2</sub>        | 0.46677 |
| ■ Prothrombin time        | 0.55352 |
| ■ Urine output            | 0.82286 |
| ■ Vasoactive drug therapy | 0.71628 |

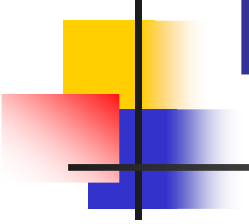


## MPM<sub>48</sub> and MPM<sub>72</sub>

Lemeshow S et al, Crit Care Med 1994, 22:1351

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- To develop model using data at 48h and 72h to predict hospital outcome
- 6,290 admissions in 6 ICUs of US
  - 3,023 completed 48h data
  - 2,233 completed 72h data

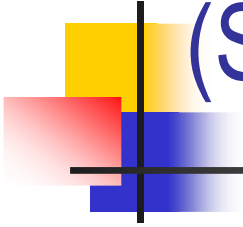


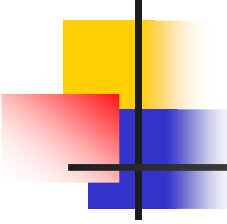
## MPM<sub>48</sub> and MPM<sub>72</sub>

---

- 13 variables were identified
  - Same as MPM<sub>24</sub> and
  - Same variable coefficients except
  - Different constant term,  $b_0$ 
    - MPM<sub>72</sub> = -5.23840
    - MPM<sub>48</sub> = -5.39153
    - (MPM<sub>24</sub> = -5.64592)

# Sepsis related Organ Failure Assessment (SOFA) score

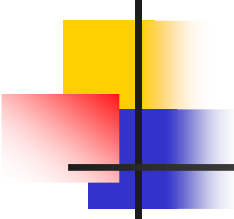




## (SOFA) score

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- JL Vincent et al
- Intensive Care Med 1996, 22:707-710
- Determine extent of organ failure &
- Rate of organ failure
- Six organs
  - Cardiovascular (MAP, vasopressor dosage)
  - Respiratory (PaO<sub>2</sub>/FiO<sub>2</sub>, IPPV)
  - Renal (creatinine, urine output)
  - Hepatic (bilirubin)
  - Coagulation (platelet)
  - Neurological (Glasgow coma scale)



## Serial Evaluation of the SOFA Score to Predict Outcome in Critically Ill Patients

FL Ferreira et al

JAMA. 2001;286:1754-1758

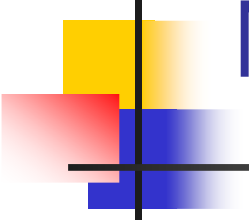
- Prospective, observational cohort study conducted from April 1 to July 31, 1999
- A 31-bed medicosurgical ICU at a university hospital in Belgium
- 352 consecutive patients (mean age, 59 years) admitted to the ICU for >24 hours for whom the SOFA score was calculated on admission and every 48 hours until discharge
- Initial SOFA score (0-24),  $\Delta$  SOFA scores (differences between subsequent scores), and the highest and mean SOFA scores obtained during the ICU stay and their correlations with mortality.

## Serial Evaluation of the SOFA Score to Predict Outcome in Critically Ill Patients

FL Ferreira et al

JAMA. 2001;286:1754-1758

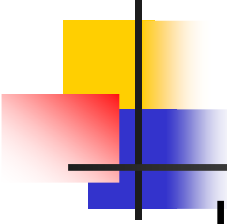
- Initial, mean and highest scores correlate mortality (M)
- Initial & highest scores >11 or mean score >5 == M >80%
- For scores with 1st 48 hours,
  - If increased == M > 50% (independent on initial score)
  - If unchanged == M 27 to 35%
  - If decreased == M <27%
- If initial score <11, & dec. trend; M<6
- If initial score 2-7 & unch./inc. trend; M=37
- If initial score 8-11 & unch./inc. trend; M=60
- If initial score >11 & unch./inc. trend; M>90%



# Multiple Organ Dysfunction (MOD) score

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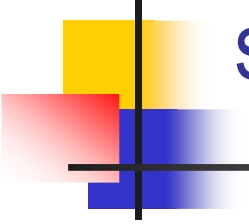
# Multiple Organ Dysfunction (MOD) score

---

- JC Marshall et al
- *Crit Care Med* 1995, 23:1638-1652
- Six organs
  - Cardiovascular (R/P = HRxCVP/MAP)
  - Respiratory (PaO<sub>2</sub>/FiO<sub>2</sub>)
  - Renal (creatinine)
  - Hepatic (bilirubin)
  - Coagulation (platelet)
  - Neurological (Glasgow coma scale)

# Logistic Organ Dysfunction System (LODS)

score



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# Logistic Organ Dysfunction System (LODS)

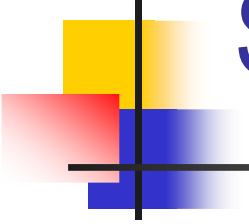
score

- Le Gall JR et al. *JAMA*. 1996;276:802-10
- Six organs
  - Cardiovascular (SBP, HR)
  - Respiratory (PaO<sub>2</sub>/FiO<sub>2</sub>)
  - Renal (urea, creatinine, urine output)
  - Hepatic (bilirubin)
  - Coagulation (platelet, prothrombin time)
  - Neurological (Glasgow coma scale)

# Logistic Organ Dysfunction System (LODS)

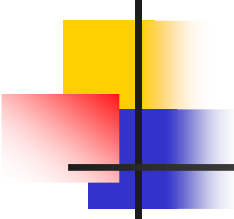
score

- $\text{Logit} = -3.4043 + 0.4173 * (\text{LODS})$
- $\text{Predicted Death Rate} = (e^{\text{Logit}}) / (1 + e^{\text{Logit}})$



# Scores for trauma

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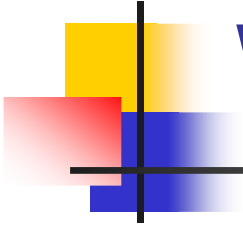


# Scores for trauma

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- Revised Trauma Score (RTS)
  - Glasgow Coma Scale
  - SBP
  - Respiratory rate
- Injury Severity Score (ISS)
- TRauma Injury Severity Score (TRISS)
  - CR Boyd *J Trauma* 1987;27:370-8
- A Severity Characterization Of Trauma (ASCOT)
  - HR Champion *J Trauma* 1990;30:539-45
- 24 h – ICU Trauma Score
  - MJ Vassar *J Trauma* 1992;32:490-500

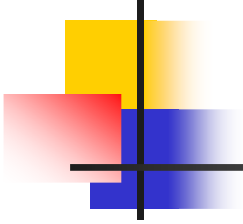
Any scoring system indicating ICU workload?



# Therapeutic intervention, nursing ICU scores

- Therapeutic Intervention Scoring System (TISS)
- TISS-28: simplified TISS





# Questions & Comments